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COVER: This stone sphinx, gazing across the Nile, is at the temple at Wâdi es-Sebua'—"valley of lions" in Arabic, in reference to the sacred avenue of sphinxes leading to it. Since the Aswân Dam was thrown across the Nile early in this century, several such monuments and sites along the river have been partially inundated during much of the year. With the construction of the new High Dam, they—as well as many others—will disappear forever. The history of the area, traditionally known as Nubia, and an account of the current efforts to rescue many of these monuments, is told by Jacques Bordaz, starting on page 10.

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Reviews

Exercises in unnatural history

Abominable Snowmen: Legend Come to Life, by Ivan T. Sanderson. *Chilton Co., $7.50; 525 pp., bibliography, index, appendixes, illus.*

A free-lance zoologist of Scottish birth and American citizenship, Ivan Sanderson has traveled over much of the earth in pursuit of his work. He has written a dozen or more popular books on zoology and has appeared frequently on television with his vertebrate companions. In the book under review he has massively attacked one of the most controversial questions of modern zoology, the evidence for and against the existence of the Abominable Snowman, or ABSM for short.

What most scientists—if they are willing to consider it at all—consider to be a restricted problem (what *is* it that keeps popping up in the rhododendron thickets and snowfields of the Himalayan area?) Sanderson has blandly converted into a nearly global one. This he has done by collecting accounts of "wild men," mysterious marauders, large two-legged animals, and almost anything like them seen moving in the woods round the world and then labeling the reported creature an ABSM.

As a result, Sanderson can cite "evidence" for the existence of such creatures from every continental land mass except Australia and Antarctica. By this not very subtle technique of expanding ABSM "populations," he ends with such a mixed bag that he has been forced to provide zoology with a new classification of this hypothetical collection of genera.

Some of Sanderson's investigations were made personally in the field (particularly in the last two years, in the area from California to British Columbia) but most of his information stems from an egregious culling of a literature that is necessarily overweighted with newspaper and magazine reports. At that, he says his bibliography (over 350 titles) is but a fraction of the works consulted. To the reader of his 150,000 words here, it is clear that Sanderson has done voluminous research.

Sanderson's technique in this book is to develop his data and ideas through several stages. First he presents—mostly in uncritical fashion—all of his ABSM evidence, however factual or fatuous, from continent to continent. This excursion in detail starting in North America and ending in the Himalayas, takes up three-fourths of the book.

Next Sanderson consolidates this material and analyzes it in terms of three kinds of evidence: *Intrinsic* (mostly skin, hair, and blood); *Cognate* (excrement and tracks); and *Corollary*, a category that includes cries, other noises, body odor, and activities (such as moving rocks). In this section of his book, Sanderson is quite critical, and downgrades much of the evidence he has previously presented in detail. The result, of course, is a substantial waste of a serious reader's time, but Sanderson seems to be shooting for a wider audience. Then, in an effort to project ABSM's into the past, he reviews the subject of fossil apes and fossil men in a way that will seem strange to professional anthropologists. He also reviews what he calls MLF (or Myths, Legends, and Folklore), and goes on to equate the product of these analyses with the facts of climate, phytogeography (plant distribution), and zoogeography. He then castigates the professional skeptics who have scoffed at the ABSM business in whole or in part, and have also failed to give ABSM-workers the necessary technical help. Finally, he states his conclusions: that at least four kinds of bipedal primates unknown to orthodox science roam the world today.

Sanderson's appendixes consist of a discourse on the philology of the names given putative ABSM's throughout the world, a primate family tree with a special chart for apes and men, a list of Himalayan animals that might conceivably have been mistaken for ABSM's, and a welcome de-debunking of Sir Edmund Hillary's recent Yeti debunking.

All of this is a large order, even for an overweight book, packed with facts, near-facts, fables, zoological principles, personal likes and dislikes, repetitions, and some downright mistakes. Most of the latter are unimportant and unnecessary, because they fall in fields peripheral to the main subject. Despite the repetitive blustering against unbelievers (which reminds one a little of Mohammed's condemnation of infidels in the sura of the Holy Koran entitled *Kafir-una*), Sanderson's is a book that merits patient reading with open mind.

The author's principal thesis is that the higher primates, particularly the pongids (apes) and hominids (Australopithecines and men) survive in more zoological forms than those now recognized, i.e., gibbons, siamangs, orangs, chimpanzees, gorillas, and *Homo sapiens*. All of these hypothetical, unrecognized forms he lumps into the ABSM category, into which he also lumps such Hominidae as the Australopithecines, the fossil men that anthropologists are coming more and more to call *Homo erectus* (Pithecanthropus, Sinanthropus, Solo Man, Rhodesian Man, and the like), and the Neanderthals, which most of us now call a subspecies of *Homo sapiens*.

Sanderson's new classification thus includes both pongids and hominids—presumably living but unrecognized—as well as others that are extinct. However, Sanderson's principal concern is with the unrecognized living forms, which he divides into four groups.

I. *Subhumans* (East Eurasian and Oriental region). These are said to be men of normal size, covered with body hair, who make a rudimentary use of tools, have some form of vocal communication, smell badly, climb rocks, and swim. They have been reported in Malaya, Yunnan, the Pamirs and Mongolia.

II. *Proto-Pygmies* (Oriental region, Africa, and possibly central and northwest South America). These are said to be pygmy-sized creatures, with black or red fur, who go about in family groups, have a primitive form of language, climb trees and swim, live in tropical forests down to the seashore and coastal swamps, and are omnivorous. Among them are the frog-eating Teh-lmas of the valley forests of the Himalayas, and certain alleged denizens of Colombia, Sumatra, and West and East Africa.

III. *Neo-Giants* (Indochina, East Eurasia, North and South America). These are the hairy, seven-foot monsters reported recently in California, and their Asiatic counterparts. Their supposed tracks show them to have very large feet, which look human in most respects, but show a double pad under the great toes.

c animals are said to use no tools, mmunicate only by loud screams, to be less human-like in behavior the first two. They include the Dzu of Indochina and Szechwan, and the uatch, or Oh-Mah, of North Amer- popularly known as Big Foot).

. *Subhominids* (South-central Eur- Nan Shan, Himalayas, and Kara- n). These alone are said to have ed canine teeth, and to drop on their kles like the gorilla. Their foot- s are the only ones that show op- ble toes. These elusive animals, n as the Meh Teh in the Himalayas, lso the only ones that seem pongid. Meh Teh is the original, classical ninable Snowman, or Yeti, with e nineteenth-century "discovery" f this ABSM business started.

the major part of his book, as we seen, Sanderson recounts numerous rts of people sighting these animals, eing their tracks, or their feces and remains, in five continents. He s with northern California, where BSM of the third and largest cate- disrupted a crew building a log- road. The creature reportedly v fuel-oil drums into a gorge, left s and excrement in profusion, and ed himself briefly in the glare of mobile headlights. Two physicians ng home late at night on Route 299 said they saw such an animal.

nderson pieces out this evidence the tale of a Swedish gentleman in sh Columbia who reluctantly ad- that he was kidnapped in his sleep- bag by an ABSM thirty-five years His captor carried him to a moun- glen where the victim was held ner for several days before escap- While a few ABSM witnesses, such his one, are willing to make their es public, Sanderson says that most em hold back through fear of ridi- . At any rate, a number of well- pped teams are now searching for creatures in the American North- . If they are really there, at least of them should be found within a onable time.

me the least credible story of this nvolves an unnamed split-level com- ity on the edge of the montane for- thirty miles from an unnamed fornia city. The children of this munity who are under seven years spend their spare time in the fields, ing with little hairy ones that come n from the trees. But, when adults e, the hairy ones dart back up in the trees. Sanderson reports that the adults know this, but are ashamed to mention it or to do anything about it. This tale leaves me completely incredulous, not so much about the hairy playmates as about the pusillanimous behavior of the adult Californians.

Another item that strains my credulity to near the snapping point is Sanderson's statement that, when he was a boy, one of his schoolmates had a three-inch, hairy tail. If his companion did, his abnormality should be the subject of a medical report rather than an item in this book, where it is completely extraneous. Inclusion of this tale suggests that Sanderson, for reasons of his own, is deliberately trying to be disbelieved.

Compared to the northwestern U.S.A. and Canada, South America and Africa are thinly represented by ABSM reports, even with Sanderson's grab bag techniques of collecting them. We do not come back into odd-primate pay dirt until we reach the Caucasus. There a Russian scientist saw one, observed it carefully, shot at it—and missed. Other Russian scientific reports from the Pamirs are of the same quality, and the evidence from the Himalayas is too well known for detailed coverage here.

Having finished his tongue-in-cheek world tour of evidence of all degrees of credibility, Sanderson drops his bland mask and becomes critical. He casts out many of the tales previously told, and analyzes the most solid items. In his array of "intrinsic" evidence, skin samples so far obtained have been taken from dried specimens kept in Nepalese and Tibetan lamaseries. Not one of these can be proved to have come from an ABSM, nor is there reason to believe that the specimens were supposed to be Yeti "scalps" in the first place. Some hair samples come from the same lamasery scalps and are equally unreliable; others were picked up near ABSM tracks. For technical reasons, these are hard to analyze, partly because of variation in different parts of the same pelage. At any rate, we know that such hairs from Nepal were not shed by bears, the principal suspects. Blood analysis has so far been inconclusive.

"Cognate" evidence consists of excrement and tracks. The supposed ABSM feces are hominid or pongid in shape. In Nepal, they contain pika fur, whiskers, and bones, chick feathers, insect "claws," and grass. In California, they are almost all vegetable, and one contains a *Trichurus* parasite (said to be found in primates other than man).

The tracks, of which many photographs have been taken and some plaster casts made (in mud), are the best evidence so far. All but those attributed to the Meh Teh (Yeti proper) are roughly hominid in form, and the Meh Teh's are roughly pongid. I agree with Sanderson that not all these tracks, if any, were made by bears or other non-primates, and that not all, if any, were hoaxes.

Sanderson next correlates ABSM reports with phytogeography and zoogeography, to show that the reports come mostly from evergreen, montane forests. He also explores world mythology, including the Book of Genesis (the latter with the help of a learned rabbi). Finally, Sanderson shows that Hillary's recent "exposure" of the Snowman was an insubstantial red herring, because the goatskin "scalp" that he exhibited on television was not supposed to be that of a Yeti, anyhow, and because his explanation of the tracks he found in the snow is contraverted by better evidence.

I view this book with mixed feelings. I wish that Sanderson had been less chatty, colloquial, repetitive, and angry. His excursions into physical anthropology and human paleontology are subprofessional. I can understand his impatience with armchair "experts," but grow tired of hearing about their delinquencies. Still, the author has made at least one substantial point. The Yeti tracks found in Nepal by several reliable explorers seem to be those of some kind or kinds of large primate. Fundamentally, it is up to the anti-ABSM partisans to prove that nowhere in the world does a zoologically unrecognized pongid or other bipedal primate exist, as well as to find the other animal that makes the cryptic footprints in Nepal.

Let us hope that the orientation of this book, transparently aimed at a wide sale to sensation-seekers, will not discourage serious professional zoologists and anthropologists from making an all out effort to clarify this all too tangled question. Let us also hope—pending the possible delivery of some such animal, alive or dead—that the experts will not be moved to withdraw even farther behind the shelter of their microscopes.

Carleton S. Coon

Three individuals have been involved with the first two volumes reviewed this month. The matter of Abominable Snowmen is discussed by Dr. Coon, of the University of Pennsylvania, who brings to the subject decades of learning as a physical anthropologist.

The problem of communications with dolphins is the joint concern of a biologist couple, the Drs. Tavolga. He is a research associate in animal behavior at The American Museum; she, Associate Professor of Biology at Fairleigh Dickinson University.

Man And Dolphin, by John C. Lilly, M.D. *Doubleday & Co., $4.95; 312 pp., bibliography, appendixes, illus.*

Scientists and laymen interested in the behavior of animals—and especially of dolphins—have certainly noted newspaper and magazine reports in the last few years in which it has been alleged that Dr. John Lilly has claimed an ability to talk to dolphins. Those who have been waiting for an authoritative

presentation of this improbable assertion now find that the press reports were correct at least in part. Dr. Lilly has at last published his own account of his investigations in this field.

It is virtually impossible to write a complete critique of this book. In almost every paragraph of every chapter, there are evidences that the work is scientifically unsound and naïve. However, it may serve as an example to young researchers—and a reminder to others—of how not to do scientific research.

Man and Dolphin begins with a prediction: that man will some day communicate with an alien species, and that this book will serve as an "elementary handbook" to prepare us for such communication. Dr. Lilly then goes on to set forth the thesis that his attempts to communicate on an intelligent level with dolphins will serve as a useful basis for communication with alien creatures, possibly even aliens from outer space.

Why dolphins? Several reasons are given for the selection of this species as Dr. Lilly's first alien communicant. In order to speak with an alien form, we must first determine whether the alien is capable of speech and has a language of its own. Once we have a positive answer to this, Dr. Lilly proposes to teach the alien our own tongue. Dr. Lilly is convinced that, of all of earth's creatures, other than man, dolphins possess a language as complex as our own and are capable of learning English.

First, Dr. Lilly is much impressed by the size and complexity of the dolphin's brain, as are most other scientists who have examined specimens of this organ. In his reaction to this remarkable brain, however, he neglects the fact that brain size and complexity are only some of the many criteria of intelligence. Indeed, the relationship of any morphological criteria to intelligence has not yet been accurately established for *any* animal, including man. Performance tests, which are especially difficult to set up for the dolphin because of its lack of manipulative ability, have in no way been standardized for this animal. Although dolphins can be trained to jump through a hoop, so can dogs. Indeed, the circus-like performances of dolphins at various marine aquariums are not in themselves indicative of any especially high intelligence level for the animal.

Dr. Lilly also assumes that man and dolphin follow the same functional patterns of development as brain size increases with age. He says that since man is capable of intelligent speech when his brain attains a mass of 1,000 grams (at 18 months), then any species with a brain of that size should be capable of an equally complex language. From this unwarranted assumption, Dr. Lilly concludes that dolphins should be capable of possessing a language. He even suspects

of maintaining a "dolphin culture," ... is transmitted by speech and re... d entirely by individual memory ...g consecutive generations.

...E next important criterion for a ...ommunications effort is that the ...es should actually possess—in addi... to an adequate brain—an "intra...es" language. Dr. Lilly's evidence ...his attribute among dolphins con... of cases in which one animal was ... to respond in some way to sounds ...iced by another animal. Based upon ...gle anecdote in which killer whales ... reported to have avoided whaling ..., he concludes that the animals have ...mmunicatory system of great com...ity, and he even describes an imag... conversation among the whales. ... thus exposing his uncritical ap...ch to animal anecdotes, Dr. Lilly ...y states that all he is doing is setting ... "working hypothesis" of a cetacean ...uage as a "temporary aid to research ...n." Later in the same chapter, he ...nds his "working hypothesis" to the ...ible existence of "tribal tongues" ...ng cetaceans. This chapter is entitled ...oiding Biased Assumptions."

...third reason for choosing dolphins ...xperimental animals is that these ...als can produce sounds not unlike ... of human speech. Dr. Lilly con...s that examples of mimicry he has ...rved are proof of the dolphins' poten... speaking powers. Dolphins are un...tionably noisy animals, and a large ...sure of the sounds they produce is in ...ection with a highly developed and ...rate echo-ranging ability (compara... to that of bats). Dr. Lilly describes ...y of the dolphin sounds that have ... reported by other investigators, but ...oes further to list a number of sounds, ...h, he contends, are "humanoid" ... represent mimicry of human speech ...ds. The list consists of: "laughter," ...onx cheers," "whistles," and, in a few ...s, "words." The latter were sounds ..., however, did not occur in any logi... context, and the author himself ad... that they were not very intelligible. ... these two facts do not stop him from ...ing still another working hypothesis. ... we assume, with Dr. Lilly, that dol...s mimic their human captors, we ...t also accept the probability that ...e sounds heard most frequently ...ld be those the animals would be ...t likely to imitate. It is awesome to ...ed to the conclusion that most of the ...munication in Dr. Lilly's laboratory ...sists of laughter, Bronx cheers, and ...stles. The point, however, is really ...pler: even if mimicry or parroting ...ld be demonstrated, the step from the ...ation of disconnected sounds to the ...munication of ideas is a giant one. ... Lilly, however, seems willing to ...ate imitation with communication.

...or any useful man-alien communication, Dr. Lilly goes on, it is necessary that there be a "bilateral kindliness" between man and alien. Dr. Lilly clearly feels kindly toward his dolphins. How do his dolphins feel about him? Not yet having established a means of communication with them, how can he tell? He seems to think that the dolphins enjoy the company of himself and his lovely wife. But it is hard to understand how these animals can feel "kindly" toward Dr. Lilly while they are confined in coffin-like plexiglass tanks and steel tubes are being hammered into their heads. The animals are then forced to learn by methods, which the author compares to those used—and used ruthlessly—on human prisoners of war. Dr. Lilly states that such methods reduce the individual human to a childish level. Without being anthropomorphic, one may ask whether this is the method most likely to produce evidence of high intelligence in a presumably intelligent animal? The surprising fact is that the dolphins tolerate this sort of treatment in docile fashion. Docility does not necessarily indicate a high order of intelligence.

One enlightening example of Dr. Lilly's research methods and his treatment of data is to be found in his discussion of how dolphins are able to communicate by taste. On one occasion, in an artificial tide pool in the Virgin Islands, a captive animal, "Baby," was heard to emit a series of sounds "as if to a distant or missing animal." At this time, a school of wild dolphins passed by at sea. They were thought to be "heading right for the area where Baby was kept." The tongue of the dolphin possesses papillae, which "apparently" contain sense organs. Dr. Lilly therefore concludes — although his conclusion is hedged — that Baby and the wild dolphins could sense each other by taste.

In the chapter titled "Implications," Dr. Lilly begins with the assumption, predicted earlier, that human beings will someday communicate with another, alien species and that the first of these "aliens" will be the dolphin. He then launches on a series of imaginative extrapolations: cetaceans could retrieve missile nose cones, deliver atomic warheads, assist in oceanographic research, herd fishes, collect rare marine specimens, and the like. As he does throughout his book, Dr. Lilly here carefully surrounds his predictions and flights of fancy with qualifications to the effect that maybe, perhaps, possibly this might, somehow, someday come to pass.

Use of the terms "language," "speech," "communication," and similar words throughout Dr. Lilly's book is extremely loose and ill-defined. At one point, language is used to mean intelligent communication of "descriptions and predictions": at another, the squealing of a dolphin in pain, anger, or fright is referred to as "talking." Many of Dr. Lilly's observations on dolphin sounds could be replicated with dogs, parrots, and other animals. Does the ability to mimic prove, or even vaguely indicate, the powers of speech?

Dr. Lilly takes the view that ". . . those who speak are those who are capable of learning language." If "one, two, three," said with very poor intelligibility by a dolphin, is indicative of the giant-brained animal's ability to speak, and therefore to learn language, what is to be said of a parrot's clear-cut, if bird-brained, "Polly wants a cracker"? Furthermore, if the parrot is then given a cracker, have we established communication with an alien species? Rover can tell us by appropriate howls and pantomime that he wants to go out. Is this a language? When a male goby utters a grunt and the female comes to him, is this an "intraspecies language"? There is no doubt in the minds of most of us that dogs, dolphins, and many other animals are able to communicate by sounds or other means (to us or to each other) their relatively simple needs and wants, but this remains a far cry from language.

Dr. Lilly has a great affection for dolphins. This is easy to understand: they give the impression of being good-natured, playful animals. This, however, is no reason to approach the study of dolphin behavior without properly controlled experiments and observations. Assumptions and working hypotheses are unquestionably useful, but to build hypothesis upon hypothesis with little or no factual basis is not science; it is harmful to the acquisition of knowledge; it tends to induce bias in experimental design, and it can lead to misinterpretation of facts. Dr. Lilly has shown us all too well how one can become absorbed in and enraptured by "working hypotheses" to the extent that one's objectivity is affected. Despite all the hedging in the book, and the frequent use of words such as "apparently," "likely," "probably," "possibly," and "looks as if," it is evident that Dr. Lilly firmly believes in his theses regardless of the weakness of his supporting evidence.

After reading the predictions in *Man and Dolphin*, the reviewers venture two predictions of our own. We predict, first, that readers of this book who do not understand the methods of science and have never been exposed to any objective study of animal behavior will cheerfully accept Dr. Lilly's theses. We predict, further, that criticisms of Dr. Lilly's work will be met by the traditional refuge: "they laughed at Galileo and ignored Pasteur." Our reply is this: without skepticism and intellectual prudence, science would not be the organized body of knowledge that it is today.

Margaret C. Tavolga
William N. Tavolga

IN BRIEF

ASSAULT ON THE UNKNOWN, by Walter Sullivan. *McGraw-Hill Book Co., Inc., $7.95; 460 pp., illus.*

THIS is a report on one of the most important and fascinating scientific adventures of all times, written by one of the most skillful and technically competent of America's science writers. It is a behind-the-scenes account of the preparations for, conduct of, and results from the International Geophysical Year —a multination scientific attack on the mysteries of the earth, the atmosphere and terrestrial space, which extended eighteen months from July 1, 1957 to December 31, 1958. It involved some sixty thousand scientists, from sixty-six nations, working at thousands of bases from pole to pole and the world round.

International co-operation was the cement that bound the separate projects of this vast undertaking into a unified whole. At the same time, competition between nations—especially with respect to satellite launchings—created national identification with some aspects of the scientific program. The tremendous popular interest in the orbiting of Sputniks, Explorers, and other space vehicles during the IGY made it even more difficult to view the total program in perspective. Mr. Sullivan sets the record straight, giving proper emphasis to preparations and accomplishments in all the scientific disciplines. Even the international political intrigue involving the Chinese People's Republic, and their eventual withdrawal from the IGY because of the participation of Taiwan, is clearly related.

One of the projects of the IGY, known as Argus, consisted of exploding two hydrogen bombs over Johnston Island in the Pacific Ocean and studying the effects on the upper atmosphere. Not only is this project lucidly described, but the description serves as an intriguing insight into the world of the journalist. (Walter Sullivan is a science writer for *The New York Times.*) For obvious reasons, many aspects of Argus were veiled in ineffectual secrecy. The reader of the book shares with the author the problems of knowledge of the detonations prior to official announcement, and the dilemma presented to a responsible journalist regarding whether or when to publish "classified" information.

An eloquent plea is made for further study of the oceans. Though some 71 per cent of our planet's surface is covered by water, we are inclined to think of the oceans as "inconvenient barriers" rather than a fertile source of food and water and as laboratories with virtually unlimited potential for revealing new information about the earth. Even the comparatively fragmentary efforts of the IGY revealed previously unknown undersea mountain ranges and new knowledge of ocean tides and currents and their relationships to atmospheric circulation.

It would be difficult to select one characteristic that predominates in Mr. Sullivan's book. There is an undercurrent of personal involvements, a weaving into the story of the personal aspirations, however, that lends unusual warmth. This feeling is most evident in the descriptions of the work performed in Antarctica, possibly because Mr. Sullivan saw the work there in person.

JOSEPH M. CHAMBERLAIN
THE AMERICAN MUSEUM—
HAYDEN PLANETARIUM

THE HEART OF THE FOREST, by Adrian Cowell. *Knopf, Inc., $5.00; 238 pp., illus.*

AN extraordinarily telling book, *The Heart of the Forest* owes much of its effectiveness to the fact that the author, originally at least, did not know a great deal about his subject. Adrian Cowell, a young Englishman, went along "for the ride" on an expedition to the still largely unexplored Xingu region in central Brazil. Sponsored by a Brazilian foundation, the trip was to start the process of opening up the area with airstrips and surveying parties, and to see what could be done to adapt the Indians in that area to the eventuality of civilization.

The forest tribes, as the author was to learn by living and hunting with individual Indians for months on end, are probably not adaptable. Despite the sympathetic efforts of some Brazilians, the Vilas Boas brothers in particular, it seems to Cowell that it may be too late, although worth the try. These dwellers of forest and jungle have a complex relationship with their environment that is a result of thousands of years. Their ways of speech and thought are scarcely translatable to our own. The Indian could not be "pacified" without losing his identity, and in fact is already starting to "despair and die." The observations in this book are intelligent and sensitive, partly because the author is without pretension in what he reports.

ICELAND SUMMER, by George Miksch Sutton. *Univ. of Oklahoma Press, $5.95; 253 pp., illus.*

THE author is an eminent bird artist, as well as ornithologist, whose drawings are well reproduced in his new book. His account of Iceland gives some indication of the nature of that wild and beautiful country, but it is chiefly a journalistic record of his many bird discoveries during the nesting season there. Most of the drawings are of chicks—a snipe, skua, oystercatcher, purple sandpiper, golden plover, or puffin—whose nests Sutton found and which he drew in the natural state. The book is written pleasantly, describing many of the hazards and delights of his task, and can be recommended to bird lovers who may be heading for Iceland, in body or in spirit.

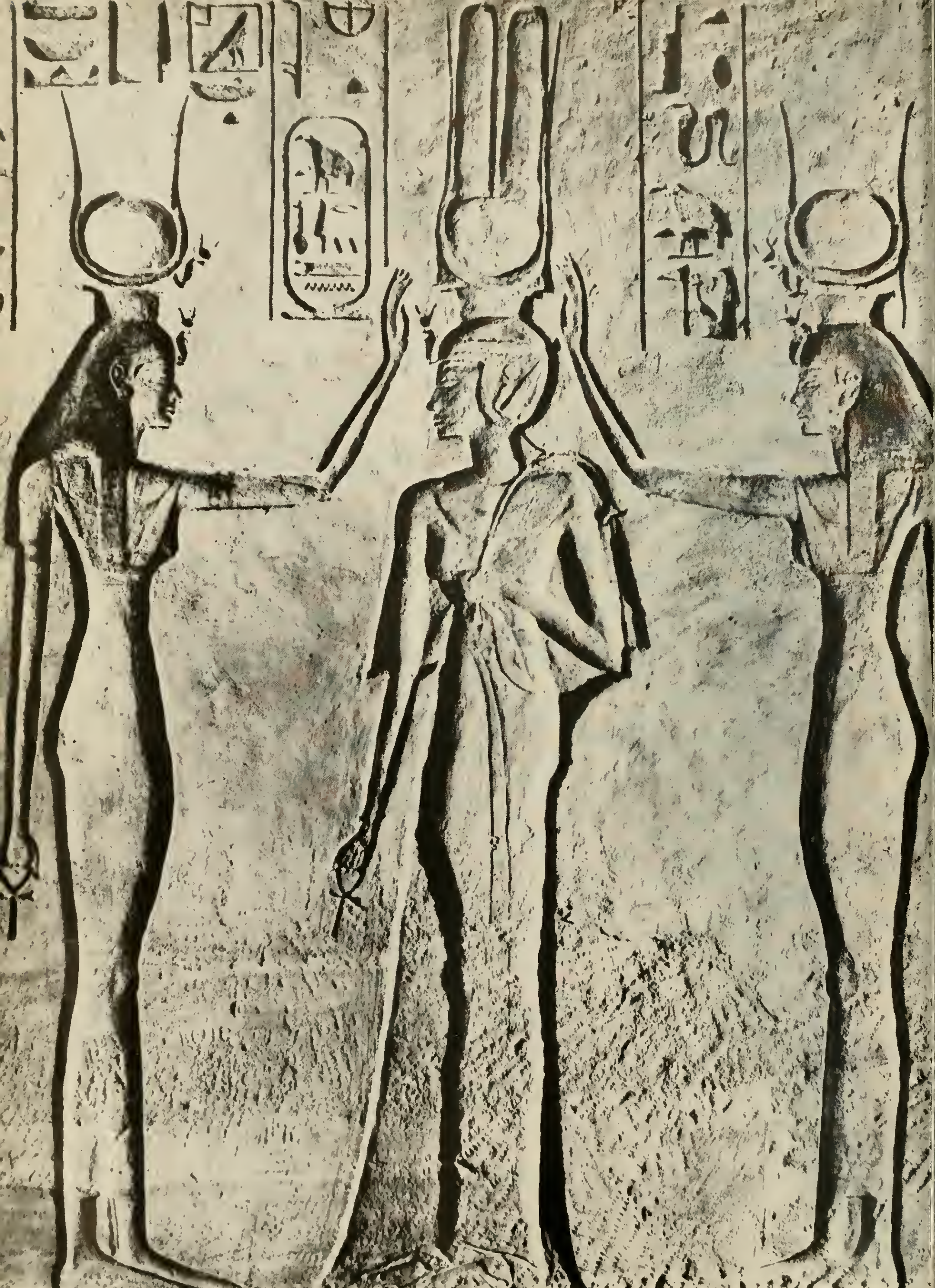
WILDERNESS, by Rutherford Platt. *Dodd Mead and Company, $6.00; 310 pp., illus.*

THIS often romantic account of the American wilderness is well told and will appeal to younger readers as well as adults. But it is as much tragedy as romance, despite the author's genial style, for the wild, rich, untouched continent is now a matter for storytelling rather than reality. Mr. Platt, for his purposes, divides the wilderness into regions: East Coast, green woods, north pine, far grass, tundra, sand and rock, monster mountain, and West Coast. The book includes a chapter on geologic origins and changes, gives the general natural history of each region, and tells many brief but exciting stories of the trials and glories met by wilderness discoverers throughout hundreds of years. The conquest is now almost complete. As the author writes in a postscript: "I find myself holding a few fragments of a living wilderness that was the depth of our being and the wealth of our land —and these are slipping through my fingers." *Wilderness* is illustrated with evocative sketches by Frances Ellis.

THE FORGOTTEN PENINSULA, by Joseph Wood Krutch. *William Sloane Associates, Inc., $5.00; 277 pp., illus.*

BAJA (or Lower) California is one of those areas that might be called underdeveloped by the progressive and aggressive modern world. For that reason, this book will be enjoyed most by those who, as the author, prefer their nature left alone. With his customary wit and philosophic concern about man's depredations, Mr. Krutch examines this partly abandoned country for its social and natural history, and finds it well worth the effort required to travel its stony roads and dry, beautiful regions.

The author is an excellent guide, never failing in enthusiasm, whether discussing that weird plant, the boogum-tree, the California gray whale and sea elephant, or the way the natives remain contented in an "economy of scarcity." Baja California is being encroached upon here and there by a modern world with the dubious benefits of airstrips and large hotels, but it is Mr. Krutch's hope that this unique area will stay at least partly primitive.



Rescuing the Nile's Treasures

swân's threat to a major cultural heritage still continues

By Jacques Bordaz

A NCIENT EGYPT endured as a civilization for three millennia, more an half the span of all recorded story, and the brilliant achieve- ents of this culture during its most ıble and creative periods have con- ıued to inspire wonder in our own nes, which seem by comparison so eting. The primary factor in Egypt's osperity — one to which this country ll owes its very existence — is the nual flood of the Nile, the river lebrated in ancient hymns as "the inger of food, rich in provisions, eator of all good, lord of majesty, veet of fragrance. . . ."

Starting in June each year, the ver — fed by the waters of the Blue ile and the Atbara, which collect the eavy rains of the Abyssinian high- nds — almost triples its flow as it nters Egypt near Wâdi Ḥalfa. By ırly September, the flood rapidly ecreases: two months later, the Nile as almost reached its preflood level.

Small variations in the volume of ile water have brought great disas- ers. Too little brings famine; too ıuch, the destruction of canal banks nd the inundation of villages. Today, s in the past, the wealth of Egypt lepends essentially on the country's bility to control, retain, and use he water of each annual flood.

Just at the turn of the century, stablishment of an efficient, flow- rrigation system (which depends on arge dams built on the river to re- listribute small quantities of water very few weeks throughout the year) ermitted the Egyptians to produce two or three crops annually, instead of the traditional single crop. The largest of these new impounding dams was the first Aswân Dam, built between 1898 and 1902, about six hundred miles upstream from Cairo. The height of the dam was increased between 1907 and 1912, almost tripling the capacity of its vast storage lake. Heightened again between 1929 and 1934, the dam had its capacity doubled once more, attaining a storage total of approximately five billion cubic meters of water in a lake that, when filled, reached two hundred miles south to the Sudanese border.

Today, the first Aswân Dam has fallen increasingly short of the needs of the Egyptian population. A country of almost 400,000 square miles in total area, Egypt contains only about 13,500 square miles (or 3.5 per cent) of cultivable land on which approximately 26 million persons must live. Thus, it is one of the most densely populated regions of the world (almost 2,000 persons per square mile). This population increases annually by half a million.

In 1952, in consequence, the Egyptian government started to make plans for a new dam at Aswân, the so-called High Dam. The project calls for a dam impounding 26 times more water than the first dam and a power plant producing six times more electricity than is now being used in all of Egypt. The reservoir, which will be by far the world's greatest man-made lake (with a capacity of 130 billion cubic meters) will for the first time make it possible to store large quantities of water over periods of several years in order to regularize the annual variations of the Nile flood. Vast irrigation and drainage projects have been planned, which should eventually increase the country's cultivated area by about one-third.

The preliminary construction for the High Dam was begun in January, 1960, some four and a half miles upstream from the first dam, with the assistance of Soviet technicians, equipment, and financing. The work should be completed by 1968. The present maximum water level, 121 meters above sea level, will start to rise in 1964 and will reach 182 meters in 1975. While no one denies that the economic benefits of the High Dam will be immense, the waters of the new reservoir threaten to destroy what has been called by one scholar "the greatest open air museum in the world." To avoid — or at least minimize — this destruction, a campaign has been launched by UNESCO in the hope that international co-operation, inspired by the respect of all men for their common cultural heritage, will allow many of the threatened sites to be saved.

THE waters of this new reservoir will cover the entire length of the province known to the ancient Egyptians as "The Land of Wawat" — or Lower Nubia — located between the First Cataract, near Aswân, and the Second Cataract, near Wâdi Ḥalfa (map, pp. 12-13). They will also flood part of "The Land of Kush" — or Upper Nubia — which extends farther south into the Sudan. What monuments, precisely, will be inundated? To appreciate the following inventory of sites, one must first learn something of Egyptian history.

From prehistoric times, the Nile

Bas-relief in Temple of Nefertari at Abû Simbel shows Queen crowned and blessed by goddesses Isis and Hathor.

This "Young Curlew," taken from a sealskin stencil, has something of the delicacy of an Oriental print.

Recently, Hudson Bay artisans have produced both stone carvings (Natural History, February, 1960) and prints for the outside world. They have been trained by a white man, James Houston, but they have brought to these enterprises their own delight in creating, as well as their skills and an intimate knowledge of animal life.

In print-making, two techniques are used: stone cut and sealskin stencil. To make a stone cut, the artist chips flat the face of a chunk of steatite, files it smooth, and polishes the surface by rubbing it with seal oil. He then carves the soft stone in low relief, in the manner of a woodcut; inks the surface; and transfers the image to fine paper by gently rubbing it with either his fingers or a small tampon. Finally, he peels the paper from the stone. The other technique transfers the design to a piece of sealskin. This is cut out, the resultant stencil is placed on a sheet of paper, and the ink is then brushed into the openings. Only a limited number of prints is taken from each of the original stone cuts or sealskin stencils.

Both the stone carvings and the prints closely resemble Houston's own art work, but the prints, curiously enough, share much with earlier native Eskimo art. I say "curiously," for the techniques are ones learned by Houston in Japan and taught to the artisans at Cape Dorset. But in early times Eskimo artists worked on flat surfaces, as when they etched figures on bow drills, and these new prints resemble the earlier etchings. Traditionally, too, Greenland Eskimo women cut out and intricately married dark- and light-colored skins to decorate their clothing. The Baffinlanders also made masks in this fashion.

The print-makers, like their forebears, depict not alone what the eye sees but what all their senses know: they portray mythical beings and dream experiences, an "X-ray" technique revealing what is concealed from the eye.

Here, then, is a world of chaos and chance, a whirl of cold and white. Man alone can give meaning to this—its form does not come ready made. The Eskimos, through art, transform this world into one of order and beauty. Their work not only invites our wonder: it reminds us that man makes his world livable by releasing its hidden forms.

A commonly observed phenomenon, rhythmically arranged, produces this print, called "Sea Gulls on Arctic Ice."

Typical of stylized nature of some prints are these "Birds from the Sea," rendered as decorative forms.

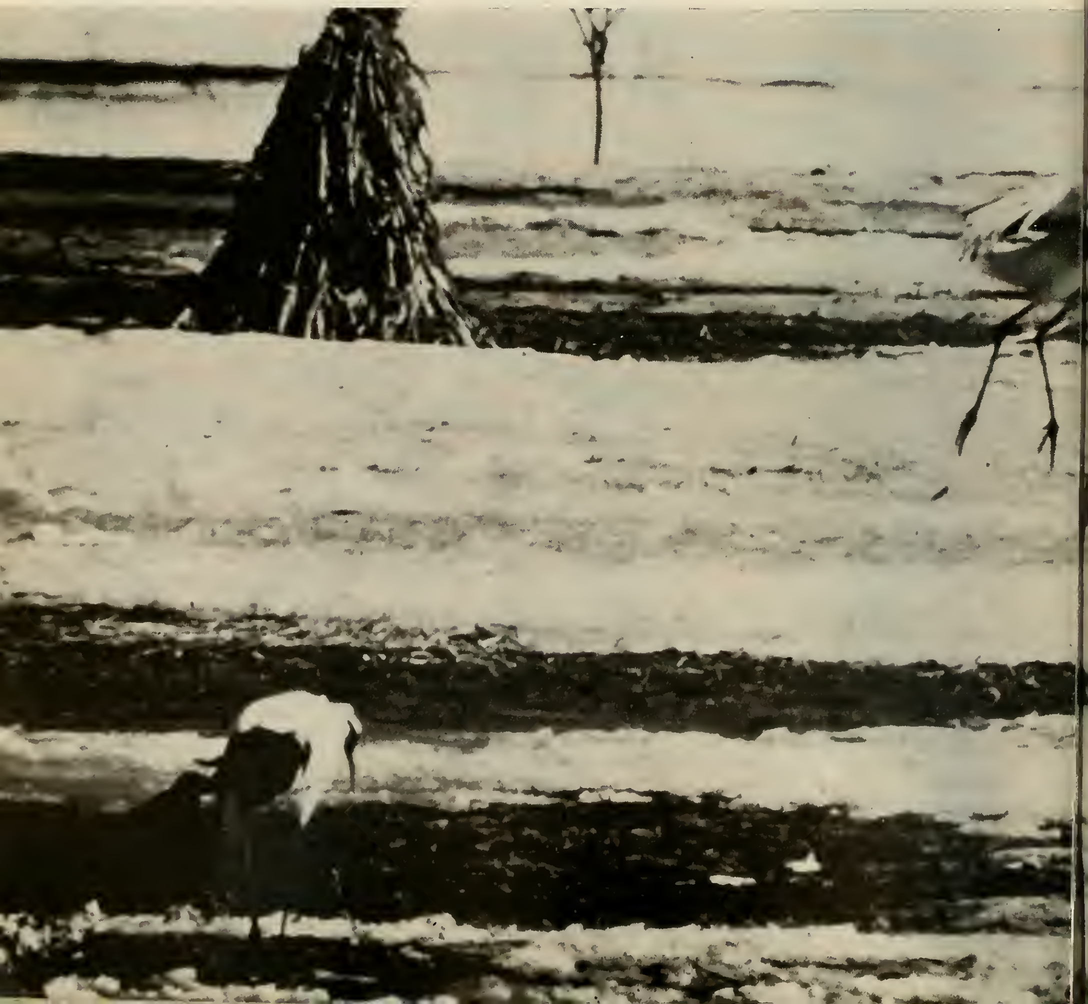
The Dance of Tanchō

THE DANCE OF THE CRANES, one of the most spectacular performances in all the bird world, has long excited man's imagination. E. A. Armstrong says: "To primitive men the cranes were something more than symbolic of the returning spring; they brought it. They were the surrogates of the resurgent sun-god, bringing warmth and fertility in their train."

Today, ritual crane dances survive in many parts of the world, and the Ainu have a circular dance in imitation of the bird that figures so prominently in Japanese mythology and art —Tanchō, the Japanese crane.

Grus japonensis, the Japanese or Manchurian crane, was formerly found as a breeding bird in Manchuria, neighboring parts of Siberia (Ussuri, Amur), and also throughout much of Japan. Today, some of the birds are still found on the Asiatic mainland, but in Japan, after the Meiji restoration in 1868 (when the Buddhist taboo on the killing of animals was lifted), the birds were exterminated throughout most of their range. Only one small colony now remains, confined to the vicinity of a vast marsh in eastern Hokkaido. The birds are now strictly protected, and under this protection they have rebounded from a low point of 20 birds in 1924 to about 180 in December, 1960.

The cranes nest in the marsh along



The rituals of courtship are observed in the last colony of Japanese cranes

By G. Stuart Keith

Mr. Keith, now an associate in The American Museum's Department of Ornithology, is an Oxford University graduate in the classics. He and his wife, who made the photographs that appear here, are now in Africa where they are studying local crane species.

the lower reaches of the Kushiro River. This marsh is almost impenetrable: the mud and water are too deep to wade through, and dense reeds prevent access by boat. It was here that the last remnants of the population managed to hold out until they were given official protection.

Outside the breeding season, practically the whole crane population spends the fall and winter in the vicinity of some small villages about twenty miles to the west of the Kushiro marshes. Here they have become very tame. Far from shooing them away, the local farmers welcome them on their lands, and several farmers even scatter corn for the birds each day.

Although sporadic dancing can apparently occur throughout the year—as with many other cranes—this becomes intensified in January and continues until late March, at which time the paired birds leave the wintering grounds and head for nearby marshes.

I have been using the word "dancing" rather loosely to refer to the action of leaping in the air and flapping the wings—an action that, in fact, is performed in a number of different behavioral situations. Perhaps the best-known of these is when two birds of a pair dance together. We may call this courtship dancing, although it is performed anew each spring by birds that may have been mated for many

TEMPLE OF ISIS and kiosk of Trajan, on island of Philae, emerge from water of subsiding Nile. Picture, *right*, shows how island appeared before elevation of first Aswân Dan early in 1900's, doomed island to almost year-long floodin

built to the north as a complement to the major temple, was dedicated by Ramses II to Hathor, the Goddess of Love, as a "monument for the Great King's wife, Nefertari, beloved of Mut . . . a house hewn into the pure mountain of Nubia, of fine, white . . . sandstone, as an eternal work."

Six giant statues of Ramses II and Nefertari, each about 35 feet high and accompanied by smaller ones representing their children, seem to walk out of this cliff temple through six inscribed portals. Behind this facade, the rock temple proper — approximately fifty feet wide — penetrates some eighty feet into the cliff and includes the usual pillared hall, vestibule, and sanctuary ornamented with paintings, reliefs, and statues.

RAMSES II's long reign (sixty-seven years) was followed by a period of steady decline in Egypt. The former empire broke up, on several occasions, into small independent states. One of these, in Nubia, was the Kingdom of Kush, with its richest lands well to the south — in the Napata region, near the Fourth Cataract, and in the region of Meroë, near the Sixth Cataract. The Kushite kings eventually conquered most of Egypt and ruled for a century (until the Assyrian invasions) as kings of the Twenty-fifth Dynasty (751-656 B.C.). However, very little has yet been found in the areas to be flooded that relates to this period — the one of greatest Kushite power.

After the Assyrian invasions, ancient Egypt lost its place as an independent state forever. Invaded and occupied by the Persians twice between 525 and 332 B.C., Egypt, upon the defeat of Darius, became part of the empire of Alexander in 332 B.C. After the great conqueror's death in 323 B.C. and the breakup of his empire, the Macedonian general Ptolemy declared himself King of Egypt.

In about 538 B.C., the King of Kush had transferred his capital from Napata to Meroë (NATURAL HISTORY, May, 1961). Numerous sites from the period that followed the transfer have been discovered in the areas to be flooded, mainly in Sudanese Nubia. Very few of these have been excavated. The frontier between Kush and Egypt fluctuated between the First and Second Cataract in the Ptolemaic period (332-30 B.C.). Both Ptolemaic and Meroitic monuments exist in this area, which had become relatively prosperous. In some cases, such as those of the temples of Philae and El-Dakka, both Ptolemaic and Meroitic monarchs have successively added to the same monuments.

After Egypt became part of the Roman Empire, in 30 B.C., a raid by Meroites on Aswân and Philae was followed by the destruction of Napata by the Romans and the construction of a fort at Qasr Ibrîm, which marked the southern limit of Roman Nubia. The Meroites never recovered from this defeat. Under Roman rule, Nubia enjoyed a prosperity that lasted for almost two hundred year Following the example of the Pe sians and the Ptolemies, the Roma emperors had themselves acknow edged as the sons of the Egyptia gods, thereby taking places in th Egyptian pantheon. Numerous ten ples were built in Nubia during thi period, notably some of the monu ments on Philae, the temple of Tâf and Dendûr, and the large temple o Kalâbsha (erected on the site of a earlier, New Kingdom temple).

In A.D. 297, following repeate attacks by nomads of the Easter Desert called the Blemmyes, the Ro mans evacuated Nubia. The Roman first set up a group known as th Nobatae — presumably Berbers fron the Western Desert — in the area, t act as guardians of Upper Egypt Rich cemeteries, probably belonging to the Nobatae, have been found a Qusṭul and Ballâna in Lower Nubia and numerous other sites from this period probably await discovery. These new guardians of the marches and their supposed opponents, the Blemmyes, finally combined forces to raid into Egypt. They were at last brought to check by the Romans and forced to sign a treaty.

In this treaty, Blemmyes and Nobatae alike were accorded the right to visit the temples of Philae and borrow the statue of Isis for certain ceremonies each year. Thus they became the last to honor the ancient gods. Christianity had become the state religion of the Roman Empire after

he accession of Constantine in A.D. 306, but it was not until A.D. 540 that Justinian, the Byzantine emperor, ordered the temples of Philae destroyed, the priests imprisoned, and Isis' statue brought to Constantinople. The king of the Nobatae became Christian at the same time and, allied with the Romans, finally drove the Blemmyes from the Nile Valley.

Once in power, the Christians showed an implacability in destroying the signs of the old religion that seems to reflect the very persecutions they themselves had suffered. Statues of the ancient gods were smashed, or defaced. Wherever possible, churches and monasteries were installed in the ancient temples. Inscriptions and reliefs were erased or covered with plaster and the walls painted with the images of the new religion. Time has now indifferently mixed the symbols of old and new. On the back wall of the sanctuary of the temple at El-Sebua', for instance, under the sacred boat of Khnum-Rē — the sun-god with a ram's head — Saint Peter, holding a large key, seems to receive from the left and right bunches of flowers offered him by the builder of the temple, Ramses II (photo. p. 19).

The Arab conquest of Nubia took place in A.D. 641 but, save for the payment of tribute to their new masters, the people of Nubia remained at first practically independent. With time, however, Arab pressure increased. Moslem settlers moved in from Lower Egypt and, in the thirteenth century, Christian Nubia finally yielded to Islam.

OUT of all this wealth of history, what can be saved, and how? The government of the United Arab Republic was the first to engage in archeological salvage in this area, by establishing in 1955 (with the assistance of UNESCO) the Documentation and Study Center on the History of Art and Civilization of Ancient Egypt. Under its auspices, Egyptian and foreign specialists have already begun to record sites and monuments, to photograph, draw and make casts, and in some cases, to

Two birds posture at left at the beginning of their duet display, under the eyes of non-participating birds at right.

Three birds in feeding flock, *below*, suddenly begin to call and dance in an apparently unmotivated burst of action.

seems to be an almost involuntary reaction to a variety of stimuli—or to no apparent stimulus at all. Robert Peter Allen, discussing similar performances among sandhill cranes, suggests that the constant jumping and wing-flapping may be partly the result of a highly nervous and emotional condition brought about by the development of the gonads. This would not account for dancing outside the breeding season, but may well explain the heightening of activity in the spring, at which season the threshold of response to the stimuli that release dancing is unusually low.

There are times when the drive is so strong that dancing will take place without any releasing stimulus. This is a strong statement to make, since one always has the uneasy feeling that there *might* be some stimulus of which one is not aware that releases the behavior. But Lawrence Walkinshaw gives a fascinating account of a young sandhill crane that he raised from a day-old chick. When it was only five days old it started leaping up and down and going through two other actions of the dance—bowing and tossing objects into the air. This bird had never seen another crane (which shows, incidentally, that the pattern or form of the dancing is innate), and I think this is an example of what has been called "vacuum activity," or activity that results when an inner drive builds up to such a point that it just "goes off" in the absence of a releasing stimulus. Among people, we call it "letting off steam." I think that some of the solo dancers among the Japanese cranes may just have been "letting off steam," even though it could be argued that there were always other cranes in sight that might have released the dancing.

Aside from the dancing, Japanese cranes have another fascinating type of behavior, which I call the "duet display." At its onset, one bird starts stalking stiffly around in front of another, its neck held erect and its head bent down until its beak is pointing at its chest, like a horse on a very tight rein. This serves to display the patch of red on top of the head. The wings of the displaying bird are just slightly raised, as are those of the bird being displayed to. The latter stands stiffly at attention during this part of the performance, and may take a few steps. After a time, the first bird walks up to the other, raises its wings higher off its back, throws its head up until its beak is pointing to the sky, and starts calling. The other bird adopts a similar posture, raises its wings and calls, and the two may continue calling thus for ten or fifteen seconds. They make a very beautiful picture—two majestic birds standing side by side and calling their duet together. When they finish their calling, the performance has been completed.

One of the principal problems in studying all crane behavior is the extreme difficulty in telling males from females. There is no plumage difference and no appreciable size difference, and I could not tell which was which. To add to the confusion, Jean Delacour tells me that the female initiates displays more often than does the male. However, he adds that when his captive pair of Japanese cranes performed the duet display, both birds raised the wings slightly off the back while calling, but that, in addition, the male lowered and spread the primaries, whereas the female kept them folded into the rest of the wing. My motion pictures of a duetting pair also show this action, with only one of the birds lowering the primaries, spreading them in a way that is reminiscent of a fan being opened. Apart from this, about the only way of identifying a male crane is by its more aggressive, more "male-ish" behavior.

When the Japanese cranes come together in a flock, a good deal of aggressive behavior takes place, and there is obviously some kind of established hierarchy among them. In one observed case, the weakest bird, which was lame in one foot, was pecked at by the others but never pecked back in return. Young birds of the flock were similarly bullied.

Aggressive display against a neighbor can be either of the "arched over" or "arched under" type (shown below). Both serve to display the red patch on top of the head. If these postures fail to impress the threatened bird, or if it fails to back away fast enough, a short run and a lunge with the beak, accompanied by a hiss like that of a goose, follows. The run is short because the adversary always backs away in time; I never saw a bird actually make contact, nor an opponent stay to fight. Often a simple threat posture is enough to send the other bird running.

Many problems remain to be solved concerning the behavior of the Japanese crane. Study of the birds at the nest should shed some light on these problems, and if the birds expand their range into areas where nests are accessible, I hope to study them again.

Aggressive behavior, which aids in establishing some kind of hierarchy in the flock, takes two forms: bird at center postures in "arched under" pattern in threatening bird at left; "arched over" position is shown in bird at far right.

Ruins of Kumma, a Middle Kingdom fortress, still guard east bank of the narrow Nile well above the Second Cataract. Semna, matching fortress on opposite bank, completed the early Egyptians' defense against Nubian raiders upstream.

grammetric techniques. This method consists of drawing the object, relief, inscription, or sculpture by means of contour lines, established on the basis of stereo-pair photographs.

This "contour map" of the object can then be used, if desired, to reproduce the original by means of a pantograph that cuts a block of plaster along the contour lines.

The documentation work is progressing well and is nearly completed for the temples of Abû Simbel, Beit el-Wâli, El-Sebua', El-Dakka, Ellesîya, Gerf Ḥusein and Dâbôd, as well as the kiosk of Qertassi, the niches of Gebel el-Shems, the temples of Abahûda, Kalâbsha, 'Amada, and Tâfa, and the tomb of Pennē at 'Anîba.

In Sudanese Nubia, most of the recording is being done by the Directorate of Antiquities and by various foreign expeditions that have obtained concessions there (among them a Franco-Argentinian and a Scandinavian mission).

Once these monuments have been fully recorded, the salvage campaign calls for relocation of the most important structures in a place of safety wherever possible. Dismantling and moving is relatively easy in the case of stone temples, but monuments hewn in rock represent a far greater problem. Except for the temples of Abû Simbel, only parts of these monuments, including sculptures and inscriptions, will be cut out and removed. Monuments of mud-brick, especially numerous in Sudan, cannot be moved and will be lost.

The relocation program calls for the transfer of 23 structures or parts of structures by the end of the summer of 1964. The cost of these operations will amount to approximately \$9 million in Egypt and nearly \$1 million in Sudan. Of the five Egyptian monuments offered in return for assistance in the campaign, two—the temples of Dâbôd and Tâfa—have already been dismantled and stored. A number of structures will eventually be installed in several man-made oases to be created nearby in the desert.

The most important and probably best-preserved of the structures to be relocated is the temple of Kalâbsha (built during the Ptolemaic and Roman periods over the remains of a New Kingdom temple). Carefully repaired before the first heightening of the old Aswân Dam, the temple of Kalâbsha is covered by reservoir water for a large part of each year, but is accessible for a short period in summer when the dam sluices are open. Kalâbsha had already been completely recorded by Egyptian and foreign experts of the Documentation Center and partially removed with assistance from the government of West Germany. Offers of help in removing other monuments of Egyptian Nubia have been made by Belgium, France, the Netherlands, Poland, and the U.S. In Sudan, field surveys indicate the possibility of removing at least four stone temples and rock tombs at Buhen, Kumma (Semna East), Semna West, and Aksha.

Philae and Abû Simbel, the largest and most beautiful of all the Nubian sites, will require the salvage campaign's major efforts. The nature of these monuments, their importance, and the beauty of their natural setting make them worthy of the extraordinary measures that must be taken.

The island of Philae, located about a mile south of the first Aswân Dam, is now under water except for periods of between 6 to 10 weeks during the summer. Its stone monuments were repaired by the Egyptian Department of Antiquities at the beginning of this century (photographs, pp. 16-17) and they have so far resisted the action of the water relatively well. But the future operation of the hydroelectric plant will cause daily variations of about 26 feet in water level — enough to erode the island and rapidly destroy the structures.

After a study made by experts of the government of the Netherlands, it has been decided that the monuments of Philae should be preserved *in situ* by enclosing the island with a series of counterdams. Work on these counterdams cannot start before the completion of the High Dam in 1968. The cost of the complete operation has been estimated at some \$6 million.

The Kennedy administration has recommended to Congress that this sum be appropriated when the progress of work requires it. There is, therefore, a fair possibility that, after half a century of submergence and emergence, Philae will reappear permanently, set in a lake all its own. After a few years, with new-planted trees reflected in the water near the island's elegant kiosk and temples, Philae should become again the incomparable "Pearl of Egypt."

When the salvage of the rock temples of Abû Simbel was first considered, in 1960, a French plan involved the construction of a vast dam that would enclose the two temples, together with their immediate setting, in front of a small lake. The construction of this dam was expected to take about seven years, cost approximately ninety million dollars, and involve more than a third of a million in annual maintenance costs to keep the site pumped dry.

Mighty ramparts mark site of Buhen, early fort below the Second Cataract.

PROFESSOR BORDAZ, of New York University's graduate department of Sociology and Anthropology, worked closely with UNESCO in preparing this study of salvage work in Nubia.

Later that year, Professor Pietro Gazzola, an Italian architect and archeologist, suggested an even more spectacular plan. This consisted in cutting free and then lifting the entire monument by hydraulic jacks to a point above the level of the future reservoir. The temples would first have to be relieved of the massive overburden of stone that lies above them. This done, the total weight of the major temple would be some 250,000 to 300,000 tons.

Cuts would then be made at the sides and back to free the temple from the cliff, and cellular walls of reinforced concrete built in place of the removed stone. At the same time, parallel galleries would be driven from a frontal cut straight into the rock under the floor of the temple, some thirty feet below the present ground level. Starting from these galleries, a supporting platform and a series of parallel walls of reinforced concrete would be built under the temple. The interior of the temple would be carefully shored up and, finally, a cellular concrete cap and frontal wall would be built to complete the supporting framework.

THESE preparations would take about three years. Thereafter, 308 large jacks, each with a capacity of 1,500 tons, would be inserted and fastened upside down to the supporting platform, with their heads resting against the tops of the parallel walls. All jacks would be controlled in such a way that they could only operate absolutely simultaneously and at the same rate. Each downward thrust would not exceed a twelfth of an inch and the total extension of the jacks would be a fraction less than a foot. When this one-foot lift is achieved, concrete blocks would be inserted between the jacks, and the jacks would crank closed. Then other blocks would be placed under their heads and another lift upward would begin. The total lift—195 feet above the temple's present level—is calculated to require two years of jacking and filling.

Once the temple reaches its final elevation, the supporting walls would be reinforced, a new landing built up in front, and the face of the concrete framework removed. A reproduction of part of the original cliff, built of local sandstone slabs, would then be set around the temple. An exactly identical process, on a slightly smaller scale, would be used to rescue the lesser temple.

Two groups of engineers successively examined the merits of these plans, and decided unanimously that the Italian project should be adopted. Both the French and the Italian schemes were considered to be technically feasible, but the latter appeared relatively simpler and safer. It seemed to the experts that water infiltration by capillary action—already observable at the base of the smaller temple — would be greatly increased by the increased pressure of water inevitable in the case of the dam scheme, and might in itself ultimately destroy both temples. It was also estimated that the Italian plan would cost some $20 million less than the French plan and would eliminate costly pumping.

Elevating the temples of Abû Simbel, preserving Philae *in situ*, and dismantling and relocating twenty-three other monuments will cost $70 million, $6 million, and $10 million respectively. UNESCO has directed most of its fund-raising efforts toward meeting the cost of these large operations (a total of $86 million). By last September, the international contributions already pledged included $20 million by the U.A.R., $1.2 million by West Germany (to transfer the Kalâbsha temple), and U.S. contributions of $2.5 million (for the relocation of monuments) and $6 million, subject to congressional approval, to preserve Philae. Other contributions — totaling $100,000 — have been made by Argentina, Belgium, Cambodia, Denmark, Indonesia, and Pakistan.

All these pledges, of course, are less than a third of the amount of money necessary to preserve the most important monuments of Nubia. In view of the large amount of money still needed and, especially, the short time that remains, the International Action Committee recommended last June that UNESCO should appeal directly to each of its 100 member states to make donations to the project proportionate to their current annual contributions to the UNESCO budget.

The financing of the final part of the basic Nubian archeological salvage campaign—surveys and excavations—has been left by UNESCO entirely to the participating expeditions. Several extensive surveys were made between Aswân and Adindân in 1907-1912 and again in 1929-1934 in preparation for the successive heightenings of the first Aswân Dam. A considerable number of historic sites were surveyed and excavated in the area below the maximum water level of the present reservoir (121 meters above sea level). The new surveys for historic sites in Egyptian Nubia will therefore be concentrated in the areas between the 121 meter level and the 182 meter level that will mark the future maximum height.

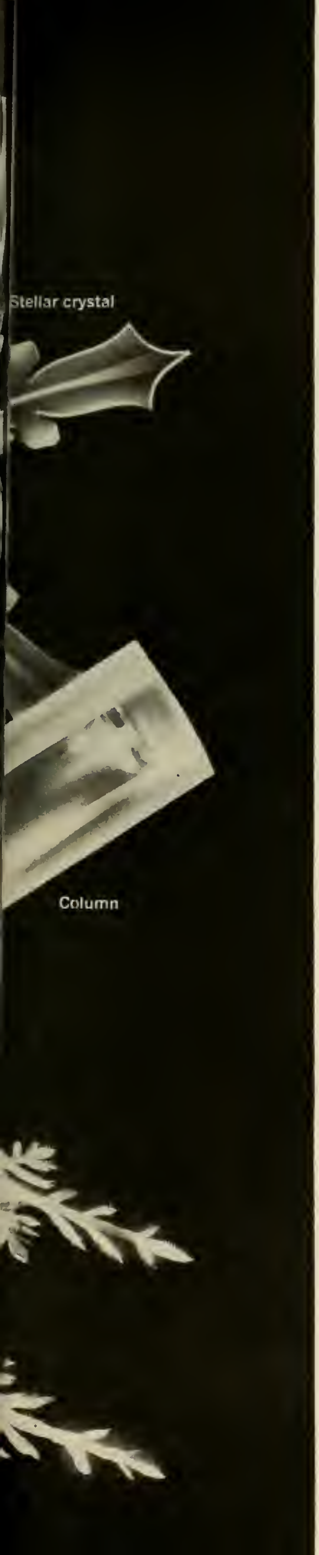
ONLY a single survey devoted to prehistoric sites was made in the area of Nubia between Aswân and Semna—in 1927-1928. This survey, which was also concerned with the geology of the area, indicates the presence in the areas now to be flooded of a rich series of Paleolithic tools, as well as many prehistoric rock paintings. Much less work has been done both in the prehistoric and historic periods in Sudanese Nubia, but recent surveys by the Sudan Department of Antiquities indicate the presence of hundreds of sites there that will vanish under the water.

The facilities offered to foreign expeditions by both the U.A.R. and the Republic of Sudan have encouraged a large number of foreign governments, individual museums, research institutes, and universities to send expeditions to Nubia. A considerable amount of work had been done by August, 1961 (see table, pp. 12-13) but much work remains. In view of the pressing needs for funds to cover this work, it is gratifying that the U.S. Congress, last September, appropriated the sum of $1.5 million for grants to help support various private American expeditions.

But as regards the major emergency—the saving of the temples of Abû Simbel—the early months of 1962 will see time run out. In the present period of international stress, success or failure of the UNESCO campaign will offer a fair measure of all mankind's interest in a common heritage.

TEMPLE OF THOTH at El-Dakka, which will be moved to another location, is now flooded during part of every year.

Six major forms of snow crystals



Wintry Art in Snow

Natural variations on a hexagonal theme

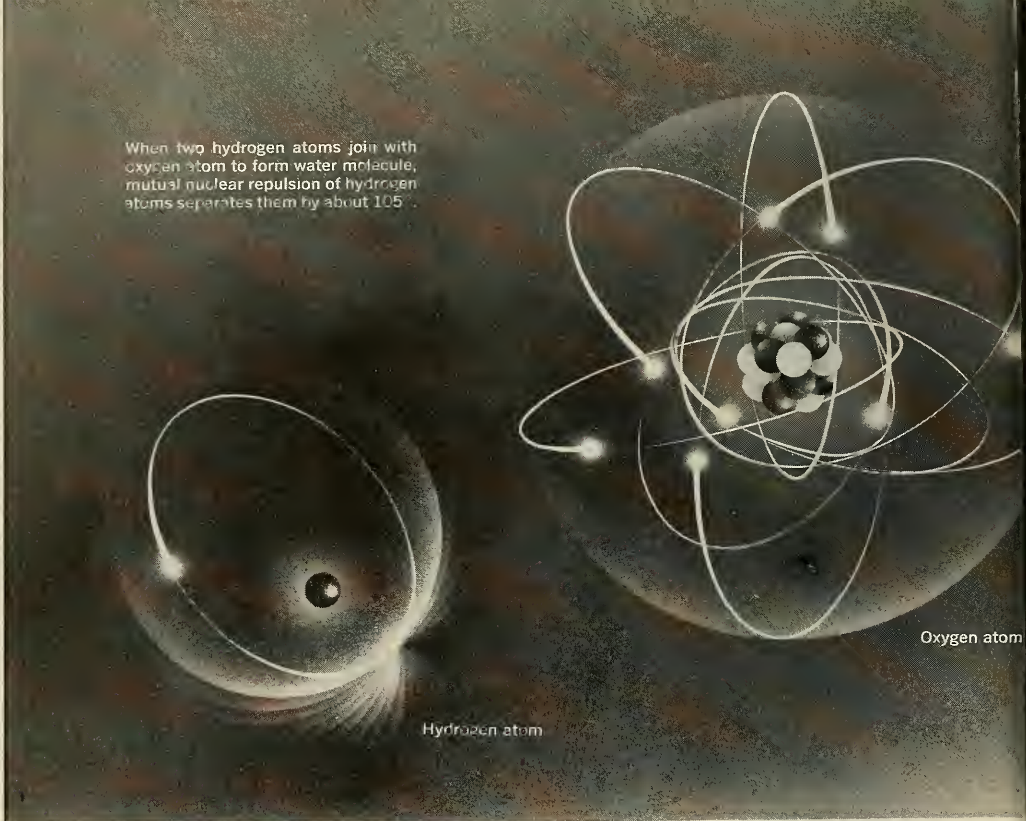
By John A. Day

Bach and Mozart occupy honored places in the world of music for, among other attributes, their superb ability to take a simple theme and weave about it an intricate melodic web. As one listens to a Bach fugue or a Mozart sonata there is no doubting the touch of the master's hand. Nature, too, is an artist not to be outdone at masterful improvisations on a simple theme. In the course of so doing, to take one example among many, nature creates one of the most beautiful objects—the snowflake.

What is a snowflake? The Japanese physicist Professor Ukichiru Nakaya summarizes the observational history in the introduction to his remarkable work *Snow Crystals*. As Nakaya relates, the earliest recorded sketches of snowflakes were made in 1550 by Olaus Magnus, Archbishop of Uppsala, Sweden, and nearly a century later by the French philosopher-scientist Descartes. These sketches antedated the microscope, or "Dutch glass" as it was first called, and were made by the unaided eye. After the invention of the microscope in the late 1600's, there was a rapid advance in knowledge of the structure of snowflakes. Most of the earliest observations seem to have been devoted to hexagonal-shaped plane crystals. Later volumes included sketches of additional forms. The development of photography provided the next giant advance. Bentley took some 6,000 snowflake pictures in his lifetime, half of which are in his famous 1931 atlas. Nakaya's own classic work, carried on between 1932 and 1944, represents the most recent major atlas of snowflakes.

The work of various observers, over four centuries, has documented the presence of many forms of snow crystals. They fall into six major classifications: plates; stellar crystals; columns; needles; spatial dendrites; and capped columns. Within these major classes, in turn, are subclasses. In terms of this class analysis the snowflake generally beloved by winter observers is a single, large spatial dendrite or an aggregate of smaller dendrites that have collided and joined in the process of their formation. But what are the fundamental ingredients of which these "symphonic" works are made? The basic ingredients are two different atoms. One is the simplest atom of all, hydrogen—the basic fuel of the universe. There is now little free hydrogen in the earth's atmosphere; that which was originally present probably escaped long ago because of its lightness. Oxygen is the second. Even though, today, some 21 per cent of the earth's atmosphere is composed of oxygen, this element did not exist initially as an atmospheric gas. In the earth's early history, all oxygen atoms were locked in chemical compounds. Eventually, with the onset of plant life, this locked-up oxygen was released to the atmosphere, and over the aeons, the present percentage was established.

The union of two hydrogen atoms and one oxygen atom produces that remarkable molecule called water. But why two hydrogen atoms? Why not three, or one? The normal hydrogen atom consists of two subatomic particles—a relatively massive proton (with positive charge) and an electron (with negative charge). The proton is nearly 2,000 times as massive as the electron and serves as the atom's central nucleus. The far lighter electron



When two hydrogen atoms join with oxygen atom to form water molecule, mutual nuclear repulsion of hydrogen atoms separates them by about 105°.

moves rapidly about this nucleus in a manner that defies observation and other than mathematical description.

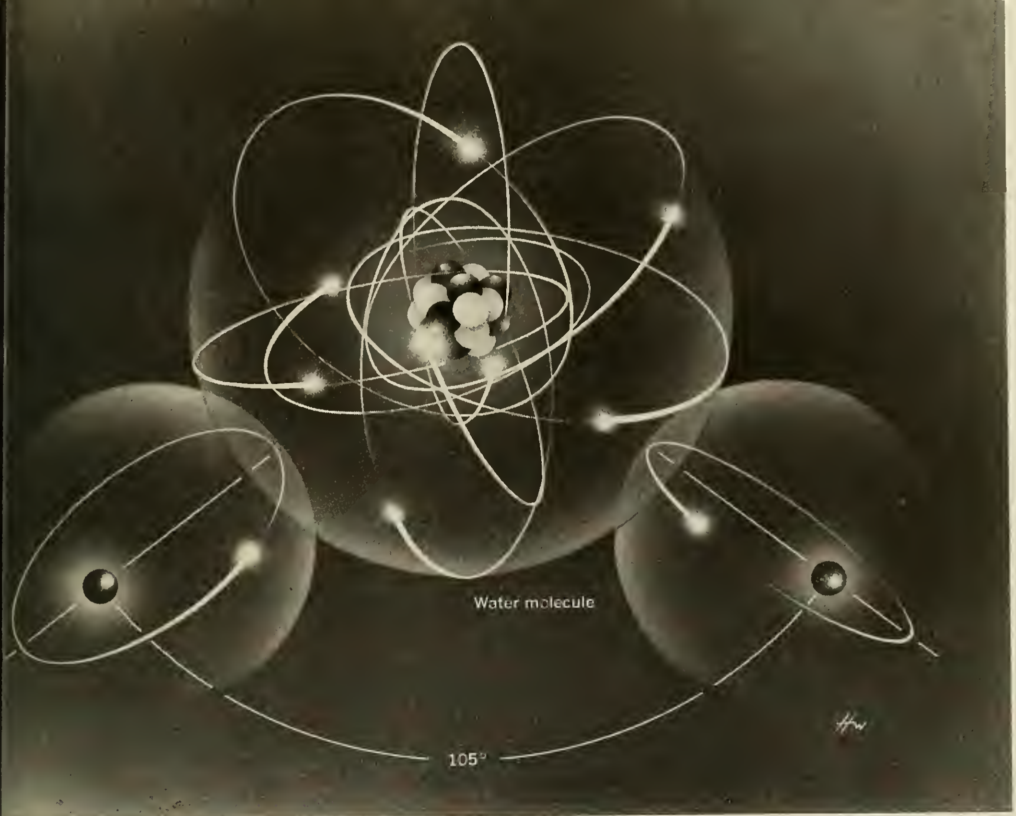
The nucleus of the oxygen atom, by contrast, is *about* sixteen times as massive as that of hydrogen, and the oxygen atom's positive charge is *exactly* eight times as large. The reason for "about" in the one case and "exactly" in the other stems from the composition of the oxygen nucleus. In normal oxygen, this nucleus contains not only eight protons, but also eight neutrons, bound in extremely close proximity. Some isotopes of oxygen, however, contain nine and ten neutrons. Hydrogen, similarly, has isotopes — deuterium and tritium — with nuclei that contain one and two neutrons respectively. The oxygen atom's structure includes eight matching negative charges: two electrons in an orbit quite close to the nucleus and six other electrons in an "outer shell." This total of eight negative electrons balances the electrical charge of the atom's eight positive protons. The neutrons, as their name implies, are electrically neutral particles.

A quarter of a century ago, the Austrian-born physicist Wolfgang Pauli set forth the important principle that various electron "orbits," or "shells," become "filled" when they contain certain specific numbers of electrons. The numbers of electrons that fill shells of progressively greater diameter are 2, 8, 18, and 32. An atom is "satisfied" when it has just enough electrons to fill a shell. This is important, for in nature stable arrangements are always preferred — and a natural sequence usually produces stability.

Oxygen's second shell contains six electrons: therefore, there is room for two more. Hydrogen's first shell contains but one electron. Thus it has room for one more. The consequence: one oxygen and two hydrogen atoms are "naturals" to join together and share electrons in a molecular union. By joining in this manner, the atoms produce a unique molecule.

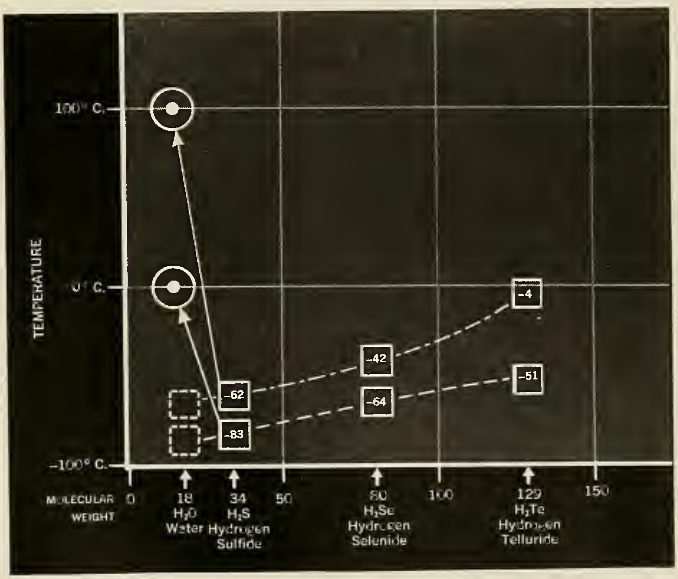
Why unique? First, the strength of repulsion of the two hydrogen nuclei for each other results in their taking positions that are radially separated by some 105° about the oxygen atom. Second, the fact of sharing electrons, to which the chemist refers as covalent bonding, means that each hydrogen atom's electron no longer spends as much time on one side of its nucleus as on the other. Instead, these negative charges now spend more time in positions between the hydrogen and oxygen nuclei. Consequently, the molecule's charge distribution becomes asymmetrical, and the result is referred to as a "polar" molecule. Therefore, the two exposed nuclear (positive) charges of the water molecule become seekers for any other atom (or molecule) with an available negative electron. This results in the establishment of the hydrogen bond—an extremely important chemical bond.

The hydrogen bond is an extremely strong one, although not as strong as the covalent bond that links two hydrogen atoms to an oxygen atom in the water molecule. Indeed, the

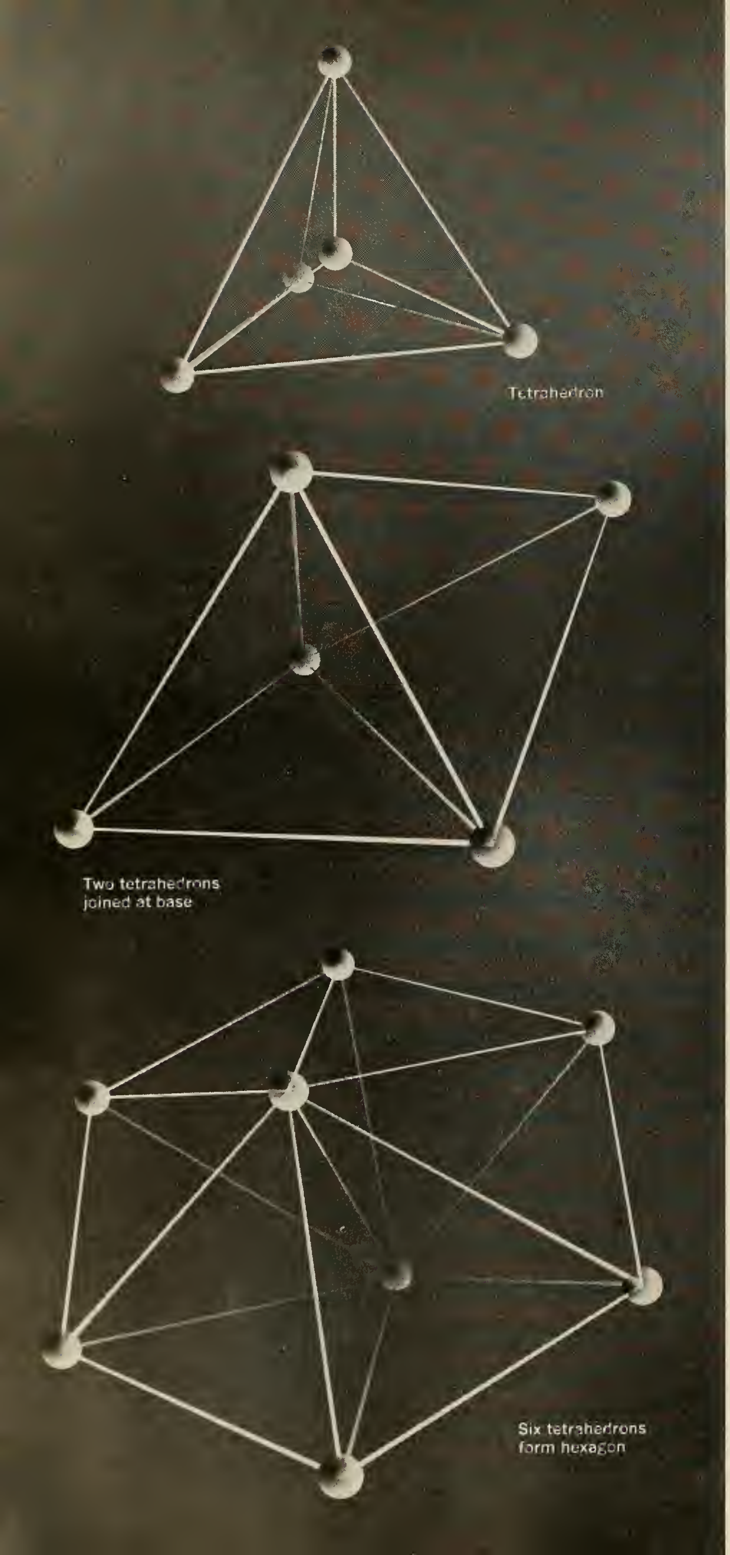


trength of this hydrogen bond gives ise to one of the unique features of vater: it is the only substance that is ommonly present in all three states—is a solid, as a liquid, and as a gas—n the range of temperatures and pressures found at the earth's surface. Various other atmospheric gases *can* be liquefied or solidified, but only in a laboratory. The solid components of he earth's crust *can* be liquefied or even turned to gas, but only with extreme temperature or pressure.

Not so with H_2O: ice, water, and water vapor are commonly present at ordinary temperatures and pressures. To show how much of an anomaly exists in the case of water, compare its boiling and freezing temperatures with those of the chemically most similar hydrogen compound, consisting of two hydrogen atoms and one other element bonded together. Hydrogen sulfide (H_2S), with a molecular weight of 34.08, has freezing and boiling points near −83°C. and −62°C. Water, with a molecular weight about half that—18.02 — has a freezing temperature



UNUSUALLY HIGH freezing and boiling temperatures of water are compared to those of other chemically similar hydrogen compounds. This anomaly is attributable to strength of hydrogen bonds between the molecules of water.



that is 83 C. degrees higher and boiling temperature that is 162 C. grees higher. This anomaly, account for by considering the relatively gre er thermal energy required to bre the hydrogen bonds joining wat molecules, may be said to be the che ical foundation of life on our plan

In the liquid state, the thermal en gies of water molecules are gre enough so that the hydrogen bonds b tween molecules are being broken co tinuously as they are formed. Wh water flows, the molecules are visu ized as rolling over each other. Wh thermal energies drop below the lev necessary to break these bonds, ice produced. The bonds that form and not break then orient the water mol cules in certain directions with respe to each other. The closeness of th molecules is dictated by the streng of each hydrogen bond, as balance by the repulsive force of the electro "clouds" of adjacent molecules.

After this atomic excursion, one better prepared to consider the sno flake. At this point, the already note 105° radial separation of the hydr gen atoms attached to the oxygen ato becomes a factor of great significanc Because of this separation, the wate molecules that make up the snowflake' ice lattice take their places at the ve texes of a four-sided geometrical fi ure called a tetrahedron. The 105 radial separation between pairs o bonding directions occurs here, to

The consequence of this separatio is that there is considerable open spac in any ice crystal lattice. The ope space between water molecules i greater when they are locked up i the ice lattice than when the sam molecules are at higher temperatur and in the liquid state. This makes ic float. Without this anomalous condi tion life as known on this planet cer tainly could not have developed. I is held generally in biology that th earth's first reproducing molecule originated in the warm, saline sea of many millions of years ago. Yet over long periods of geological his tory, temperatures in the earth's pola regions have dropped below freezing Had water the characteristics of most substances—which shrink as freezing

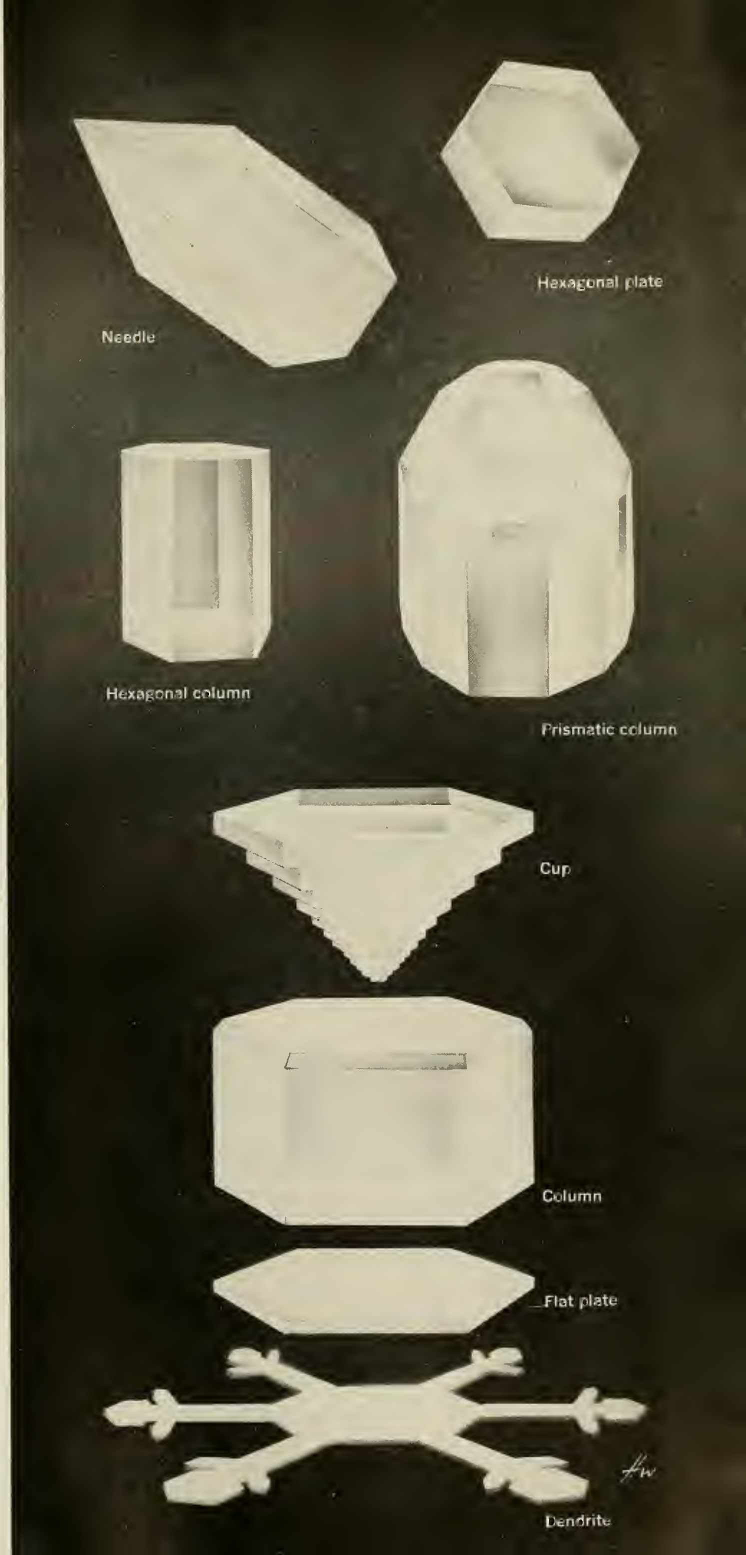
Six tetrahedrons form hexagon (lower left), basic ice pattern. Tetrahedron has four water molecules at vertexes and one at center, shown only at top.

urs—the solid form of water would
e settled to the bottoms of the polar
s. There, insulated from solar heat,
submerged ice would have accumu-
d, spreading its chill to the rest of
oceans. Such a situation could not
: have inhibited the development of
rine life forms.

\s it is, the expansion that water
lergoes as it freezes—and the addi-
ual fact that it is heaviest at 4°C.—
ans that all ice lies atop ocean, lake,
stream, protecting the life forms
it swim in the environment below
m the rigors of winter clime.

An easy way to visualize the open
ucture of ice is to make six tetra-
lrons, using toothpicks and glue,
n arrange them together. The re-
ting figure is a hexagon. It is now
atively easy to see that additional
lecules deposited on this basic crys-
form would produce additional
xagonal patterns inscribed within
xagons. It also becomes possible
visualize different planes fixed by
locations of groups of molecules.
iese planes make up various geo-
trical figures, and these figures, in
rn, are the forms that are assumed
growing ice crystals.

How do these theoretical consid-
erations relate to the types of
crystals actually formed in nature?
mparing theoretical and actual sit-
itions, one concludes that the factor
termining the type of crystal must
the same factor that determines the
owth rate from a particular crystal
ce. If a crystal grows primarily in
e direction of the basal face it will
come a hexagonal column; if it
ows toward the prism face it will
come a plate; and so on. What, then,
uses the difference in growth rate?
his question is a present concern of
oud physics research. In his book,
he Physics of Clouds, B. J. Mason,
ie well-known English cloud physi-
st, discusses at some length the fac-
rs that control the growth form of
n ice crystal. He suggests that the per-
nent factors are: internal structure
f the crystal, its surface structure, its
iodification by impurities, environ-
iental conditions of temperature and
upersaturation, and fall motion of the
rystal through the atmosphere.



IEXAGONAL MOTIF recurs in the plane, olumnar, and prismatic ice crystals upper right) and in basic shapes of nowflakes, some of which are shown.

Dr. Day, who is now an associate professor in the physics department at Linfield College, McMinnville, Ore., was formerly a meteorologist with Pan American World Airways.

One result of laboratory experiments is to show that the type of crystal produced depends on temperature (once a minimum level of supersaturation is attained) and that there is an alternation of crystal habit:

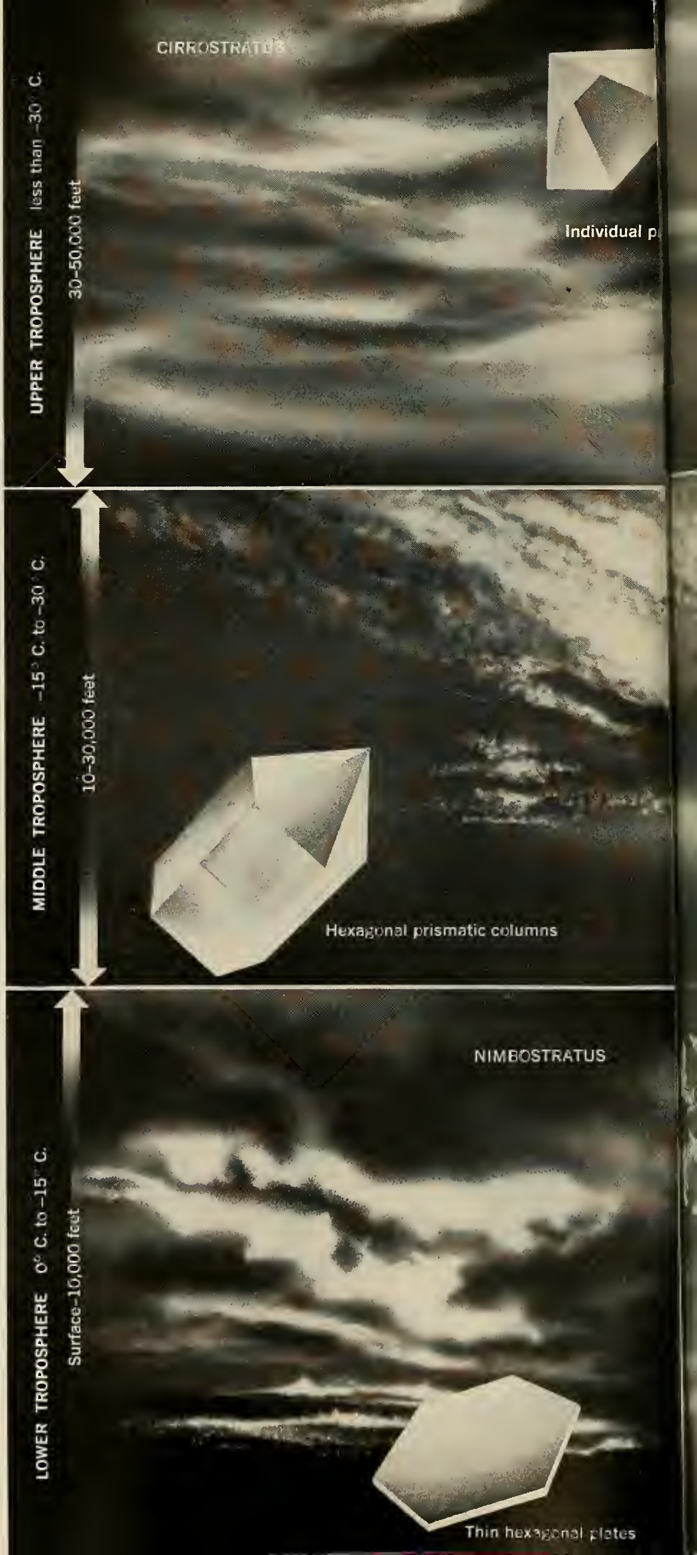
0°C. to –4°C.	simple clear plates
– 5°C. to –9°C.	prisms
–10°C. to –25°C.	hexagonal plates
–25°C. to –40°C.	prisms

This corresponds rather well to the varieties of crystal occurring in different cloud types (shown in the illustration that appears at right).

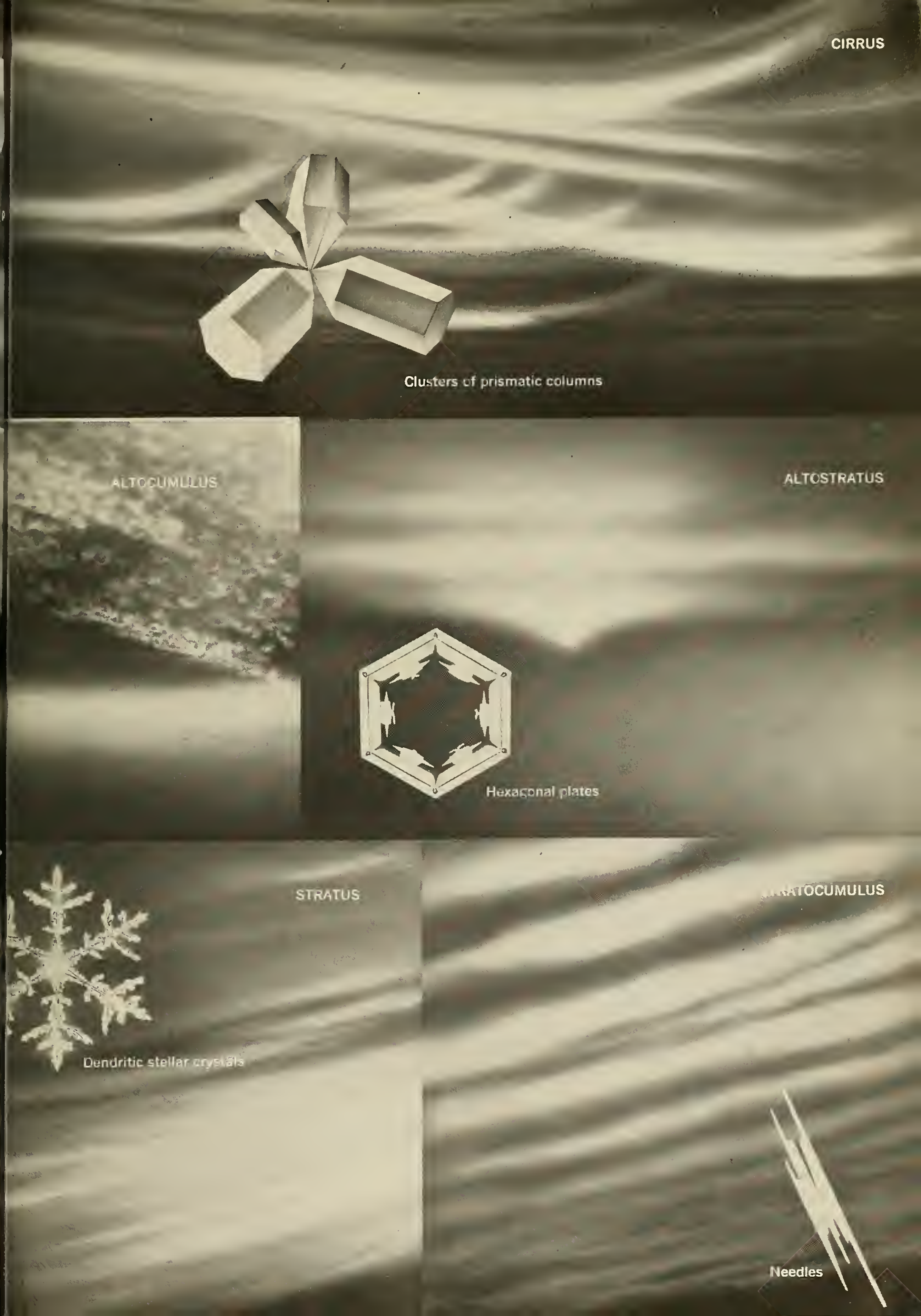
When using the term "snowflake" one usually thinks of the richly branched, flat crystal known as a dendrite. How does this form? Starting with a falling hexagonal plate, with its maximum cross section perpendicular to the fall direction, water vapor molecules of the environment will arrive preferentially at the corners of the plate. After the crystal reaches a minimum dimension of about 100 microns the corners will start to sprout and grow while the vapor supply lasts. This type of crystal will develop best in a supersaturated atmosphere, such as is found in a supercooled water cloud.

It is often said that no two snowflakes are identical. Is this a valid statement? An appropriate reply may be suggested through analogy. Are two human beings identical? The answer is categorically and confidently, No. Biologically the closest approximation to identity would be the identical twin. Yet, even in this case, the possibility of variation exists in the way the individual reacts to his environment. Thus: close similarity—yes; identity—no.

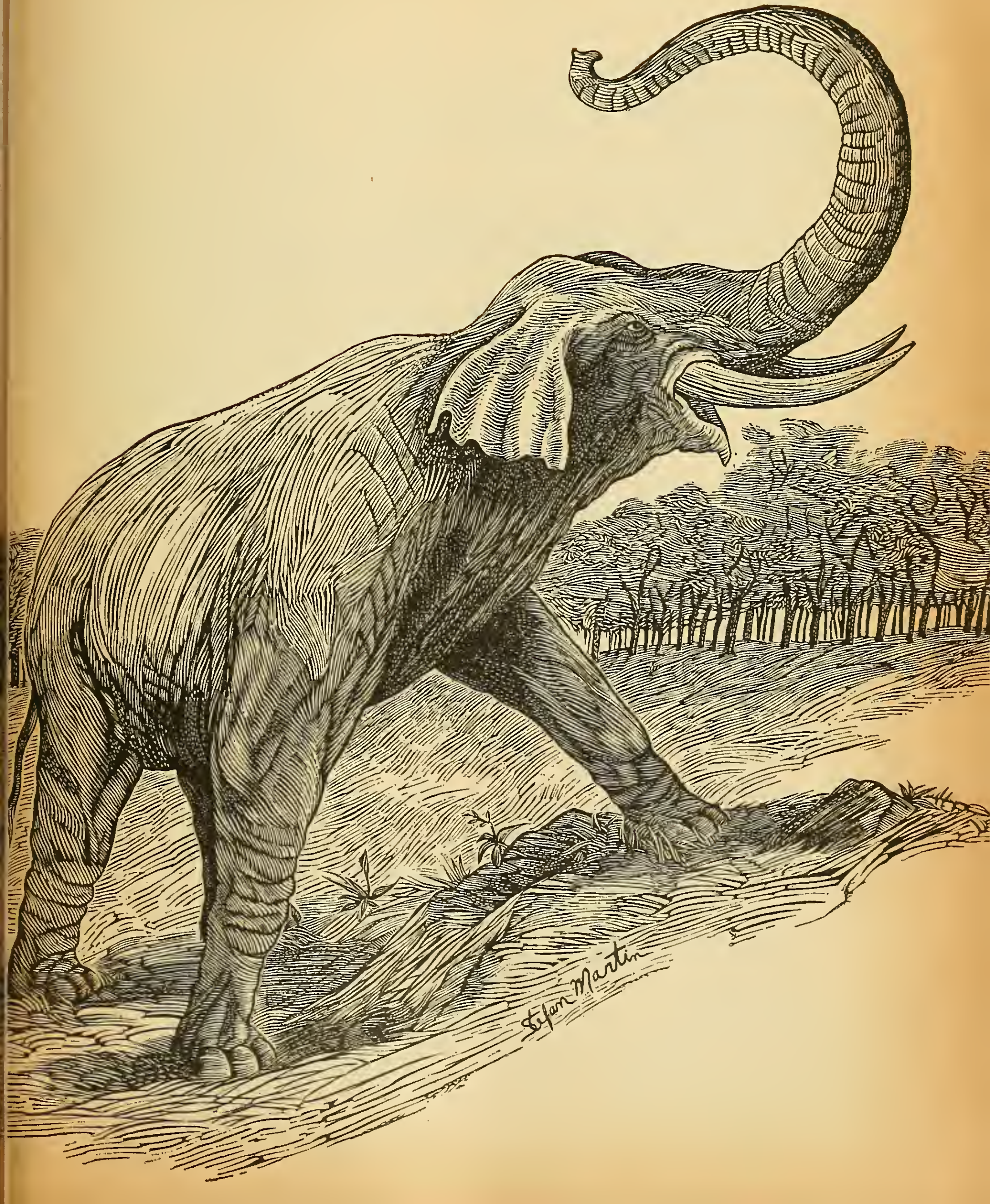
The snowflake is an inanimate object immersed in a changing, nonrepeating environment. Therefore, it may be said with confidence that although many snowflakes closely resemble each other, it is reasonable that no two will be identical: each will be a distinct but fleeting entity, a variation on a basic hexagonal theme.

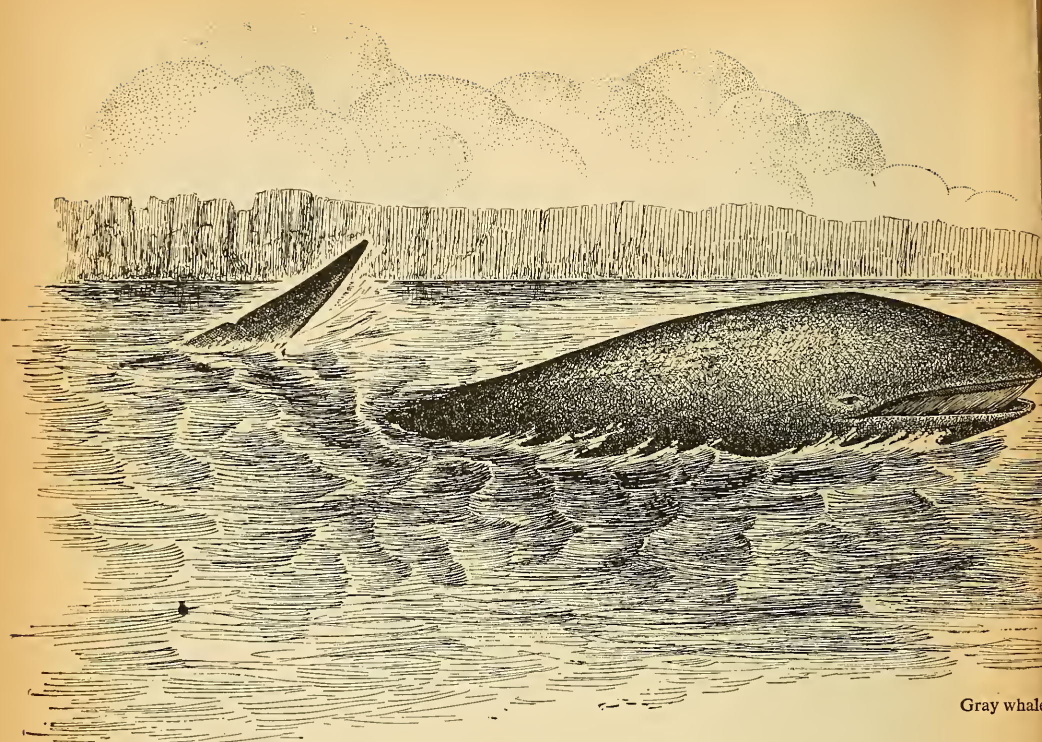


Predominant crystal forms in various subfreezing clouds relate well to the artificial ones made in laboratory at approximately equivalent temperatures.


CIRRUS
Clusters of prismatic columns
ALTOCUMULUS
ALTOSTRATUS
Hexagonal plates
STRATUS
Dendritic stellar crystals
RATOCUMULUS
Needles

This is the 114th
of NATURE MAGAZINE's
special educational inserts





Gray whale

MAMMAL ABUNDANCE

Extinction or overexpansion of species can be controlled by man

By E. Laurence Palmer

Among the many difficulties confronting man today is a serious and somewhat paradoxical problem that might best be summed up under the general term "mammal abundance," which is concerned with two diverging tendencies. First, certain mammals multiply to a possibly disastrous extent; second, certain other mammals disappear entirely from the face of the earth. Mammal abundance, or lack of abundance, has become a critical subject—a problem for which a solution must be found if man and his fellow mammals are to continue into the distant future in a relationship remotely approximating that existing today. All of us, if we so desire, may make some sort of contribution to the solution of the mammal population problem; but to do so intelligently, we must first recognize its nature and its challenge and follow recognition with the adoption of sensible mammal practices throughout the world.

This article was originally planned to deal solely with those mammals in immediate danger of extermination, and to provide some ideas for discussion topics at meetings of the International Union for the Conservation of Nature and Natural Resources. This session was scheduled to be held in Africa during 1963. However, the social and political convulsions currently besetting the great African continent have made cancellation of the meetings necessary, and it is to be feared that by 1963 at least some mammals of great scientific and aesthetic interest may no longer be found in their free and wild state.

But the mammalian problem does not lie solely in the extinction of current species. Paradoxically, in the absence of atomic warfare or some other catastrophe, an equally grave difficulty is presented in the need for reasonable limitation of mammal numbers. Here we will present a sketch of the problems associated with mammal scarcity, overabundance, and normal balance, considering both man and his domestic mammals, and not limiting ourselves to free wild mammals or to those of any particular geographic area.

Over the centuries man has associated himself with the "lesser" mammals. The domesticated zebu, e well-known example, is a creature that has in certain rts of the world been the servant of man since perhaps 00 B.C. Saddled, a zebu can carry a man for some teen hours at the rate of six miles per hour and can ul a carriage thirty miles in a single day. As a draft imal, its movements can be controlled even by a child; furnishes milk and meat, and is adaptable to regions drought and sparse vegetation.

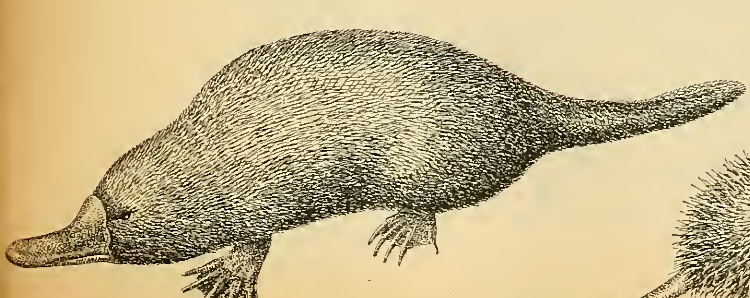
Zebus were introduced into the United States in 1853, id again in 1906. At about this latter time, they were sed in evolving certain desirable qualities in our own Vestern ranch cattle. One zebu bull, over the course of is lifetime, sired no fewer than 150 other zebu bulls, hich were the basis for the establishment of the Santa iertrudis breed of cattle, officially recognized in 1940. his line of stock now produces bulls that weigh as much 1,800 pounds, and cows that weigh up to 1,200 pounds. four-year-old steer of the breed may weigh as much s 1,400 pounds. The mammals are mild-tempered, gain veight on grass alone, can travel long distances with but ttle water, and are resistant to ticks and the Texas fever hat is associated with these insects. The ability of the reed to thrive on land that will not support other domestic cattle has meant, in some parts of the world, meat or men who might otherwise have been without it. In his respect, the advent of the Santa Gertrudis breed has mpinged somewhat on the field of sociology, since hungry people are also, not infrequently, dangerous people.

Americans like to feel that they can be of assistance o other peoples of the world. The United States record of agricultural production—and especially the improvement per acre on farm lands that have been under cultivation for a long time—has not, we think, been matched or even approached by any other nation possessing lands of equal or higher potentials. Our discovery and understanding of the process of artificial insemination has made it possible for a single bull of demonstrated superior qualities to fertilize 200 cows at a single service, and to father 6,000 calves a year rather than the normal 30. Such calves reach a marketable condition more quickly, at less expense, and bring a higher market price than do those not subjected to mammal management.

We know how to produce more domestic mammals more quickly and economically than ever before. If we can spread this knowledge into the parts of the world that still face periodic starvation and resulting tragedy, there may well be no need whatsoever for destroying jungles for grazing lands—jungles that support the relatively few remaining gorillas, or the lands that are now habitats for the lion, zebra, giraffe, rhinoceros, and other great mammals. Unless the human mammal can demonstrate in Africa and Asia—and, for that matter, in North America—that he can make the maximum use of lands already in cultivation, it will be difficult for him to explain to future generations why it was necessary to despoil other land areas that had for untold years been the habitat of great herds of wild mammals. In the United States, we have demonstrated that we can, if we have the will, save representative groups. We have done it with pronghorns, deer, and smaller mammals. It has been accomplished through wise legislation at federal and state levels that resulted in the establishment of a system of parks, refuges, and other nationally owned and protected properties, together with sensible hunting laws.

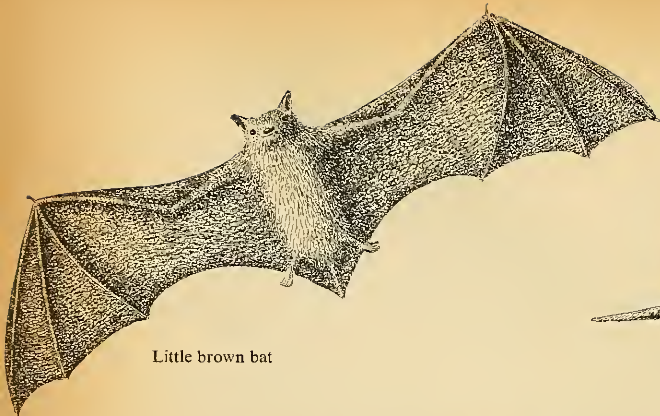
In some other parts of the United States it has also been shown that an abundance of wildlife can be compatible with a large domestic mammal population. The writer lived the first part of his life in the great agricultural state of New York without ever having glimpsed a deer in the wild. In recent years he has seen the deer population on his own lands build up—somewhat to the detriment of plants he wished to grow—and then be reduced to a normal herd through wise supervision and the harvest of surplus mammals that would otherwise pose a threat to orchards, gardens, and forests, as well as to ground cover needed for the herd's own existence.

Our agricultural colleges have increased the productivity of our lands so greatly that we can better face the prospect of exploding mammal populations, both wild and domestic, and even that of man himself. A California farmer is reported to have said that there was no need for him to learn more about making his farm increasingly productive because: "I got more knowin' now than I does, and until the doin' I does catches up with the knowin' I has, I can't see no reason for knowin' no more." Obviously, the farmer was only partly right. It seems apparent that if we use wisdom in the management of our lands and of the plants and animals that live upon them, Americans might never have to face some



Duck-billed platypus

Virginia opossum



Little brown bat

Big short-tailed shrew

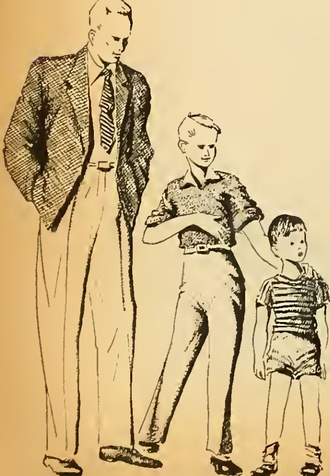
of the economic upheavals that have so frighteningly afflicted other parts of the world.

It is interesting to survey a few of the uses to which man puts other mammals, both domesticated and wild, aside from their obvious use as food. Mammals have long been, and probably will long continue to be, used as reliable draft animals for special purposes, such as the exploration of very rough terrain. They are workers that do not depend upon the gasoline pump, but instead can largely live off the land. Traditionally they are pressed into service as replacements for the gasoline engine during times of war or natural disaster. Some of the basic materials of industry are derived from mammals, including the leather of our shoes or the casein that is widely used in plastics and other materials. Orchestras will, so far as we can guess, continue to scrape on the intestines of mammals to produce sounds. These are only a very few of the more obvious uses.

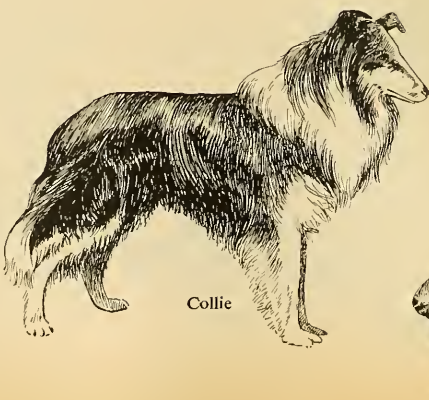
Mammals will certainly continue to be utilized in multiple ways in the science of healing. In addition, certain mammals are constitutionally so similar to man himself that much knowledge can be acquired from studying them. Living "lower" mammals will certainly be employed in place of man in some of our explorations of space. The psychological and behavioral studies of other mammals give man an insight into his own nature.

Many people find difficulty in understanding the concentrated efforts of scientists, conservationists, and others to preserve at least a representation of our threatened mammal species. They do not realize how much is still to be learned about every mammal, and forget that once a species is extinct most of the opportunity for learning has vanished with it. As an example, the blood of some lemurs has a peculiar coagulative property that might well be useful in cases involving the treatment of human blood; we could hardly afford not to explore such a possibility. But aside from studies directly affecting man's health and well-being, there are those basic researches that help to explain the world around us—as it was, is, and might be. Such studies will not necessarily make the world a better place in which to live, but it is certain they will make it a wiser place.

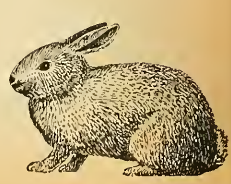
In evaluating the position of threatened species, a wider understanding of the use of other mammals in relation to humans is necessary, notably on the African continent. For instance, it is very likely that one of the factors that will hasten the extermination of the rhinoceros is the belief, held by some Africans, that rhinoceros "horns" have a high aphrodisiac value. This conviction



Man



Collie



Eastern cottontail

s so firmly established that powdered rhinoceros horns currently sell for prices extraordinarily high for the economy. However, it would be difficult, and perhaps unwise, for sophisticated societies to attempt to change basic convictions of newly emerging civilizations, no matter how contrary to their beliefs contemporary medical evidence might be.

The relations between man and many mammals are mutually beneficial. Dogs, to use the most obvious example, have been man's hunting assistant since time immemorial. They have helped their masters by protection, guidance, and companionship, and have become indispensable in many areas of occupation. Man, in turn, has provided dogs with shelter, food, and admiration. There is little danger of the dog becoming extinct.

It is just as likely that the horse will survive the mechanizations of the human mammal, if for no other reason than to provide recreation and a chance to lose the local medium of exchange. In New Zealand, where valuable agricultural lands are severely limited by the sea and mountains, farmers have resented the use of prime agricultural land for the support of race horses. So strong, however, is the national interest in "the races" that farmer protests are futile—apparently many New Zealanders prefer betting to eating!

In discussing mammals not so closely associated with man, it is helpful to know the principles that determine mammal scarcity or abundance. Only then will we be in a position to exert some influence on populations. Some factors are little understood, and some may be wholly beyond our ability to control; few will be found to apply equally to all mammals.

One of the basic factors influencing mammal abundance is that of food, the demands for which vary greatly from species to species. The problems of mammals with specific food requirements will quite obviously be different from those faced by mammals capable of changing their diets. A duck-billed platypus, which has a daily food requirement of at least one-half its own weight in invertebrates such as crayfish, would quickly starve in an area that would amply support a gray whale. Not only must the food be suitable to needs of a particular mammal, but it must also be abundant when needed.

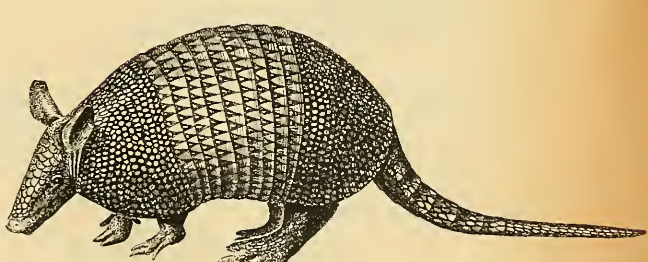
DR. E. LAURENCE PALMER, for many years director of NATURE MAGAZINE's educational program, continues his special inserts in the pages of the combined magazines.

MANY mammals travel great distances in the course of a year in following their food supplies, or in obtaining new ones. Seals, for example, follow their supply of fish; when the American bison was in its free and wild condition, it moved north or south over the Great Plains according to grazing conditions. Some mammals meet the seasonal variation in food supply simply by suspending their eating programs and going into hibernation. Others, like the wolf, gorge themselves with food when it is available, and go without when it is not. The human has eliminated mammal species in various parts of the world solely by destroying their food sources.

Fire is of great importance in regulating mammal populations. A large forest fire, for example, may eliminate the breeding stock of many different sorts of mammals over a considerable area. Ordinarily, the only avenues of escape open to most mammals during a forest fire are accidental ones; a fleeing mammal may tumble into a pond or lake, or find an unused burrow. However, even such accidental havens may be only temporary; the fire will probably have destroyed the mammal's normal food supply in any case, and the creature then will face the prospect of starvation.

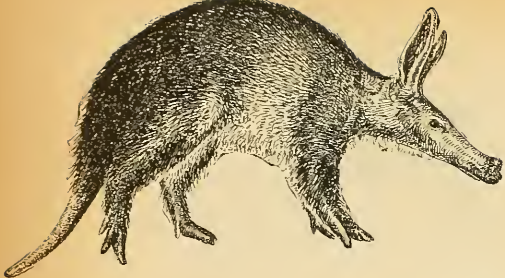
Mammalian survival also depends upon a suitable supply of water. Waterholes the world over are the gathering places for mammal populations. Mammals that are able to dig into the earth for their water frequently survive conditions that would be fatal to others. Some desert animals, like kangaroo rats, are able to derive enough water from their food to satisfy their needs. The engineering skills employed both by man and by other mammals in securing water supplies are noteworthy. Man himself has been experimenting with methods by which he can derive fresh water from the seas, with an eye to almost inescapable future shortages.

Many mammals are quite specific in their temperature tolerances, and extremes of temperature have a considerable effect on the local abundance of the mammal pop-



Nine-banded armadillo

Pangolin

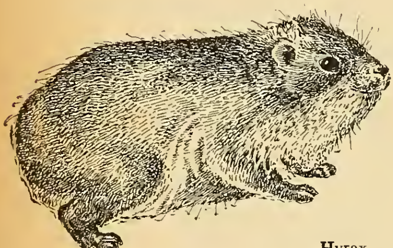


Aardvark

ulation. Only man has developed artificial means for living comfortably in areas that were formerly proscribed to him. The development of central heating and the air conditioner, however, means that man will occupy new territory, to the possible detriment of mammals that are better equipped by nature to survive hostile conditions of extreme temperatures.

Floods, also, greatly influence the abundance or scarcity of mammals. Most vulnerable to flooding are, perhaps, those mammals that live underground; great populations of these latter are regularly drowned during times of high waters. Also, flooded lands tend to bring predator and quarry together, so that danger to the latter is not in floodwaters alone, but also in more imminent attack.

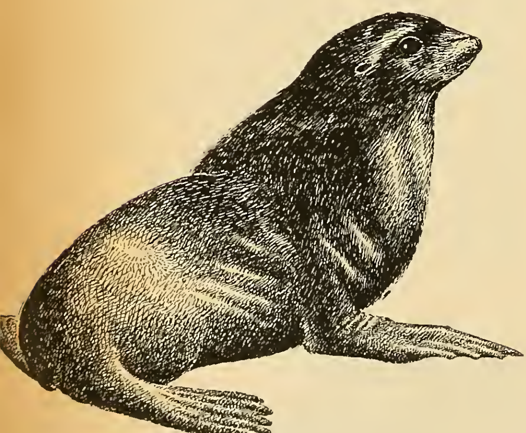
Some people think that predation is a major factor in mammal abundance. Others, with some reason, point out that few mammals are ever completely driven from any particular area by any of their natural enemies except man. Populations of predators and prey usually rise and fall without the complete destruction of one or of the other, although man himself has destroyed, in some areas, the predators that kept many animals at a comfortable population level. To understand the rise and fall of mammal populations, an understanding of the nature of individual species is necessary.



Hyrax

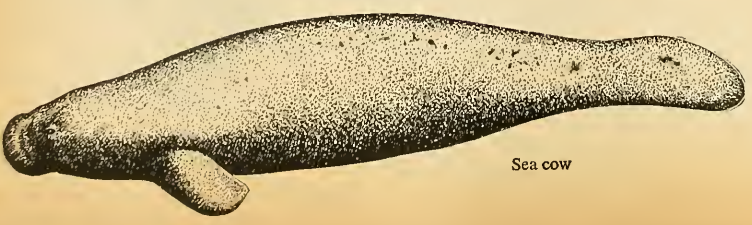
MAMMAL individuals originate with the meeting of a male and a female of a given species. The gestation period of the female varies greatly; for example, in the opossum the young may be born only twelve days after copulation, while the Asiatic elephant may carry her young for as much as eighteen months. There is also a tremendous disparity in size between the young at birth in these two examples. The newly born opossum is the size of a honeybee; the newly born elephant may stand three feet in height and weigh 200 pounds.

Many male mammals never see their young, going their ways as soon as they have mated. Others remain



Northern fur seal

Norway rat



Sea cow

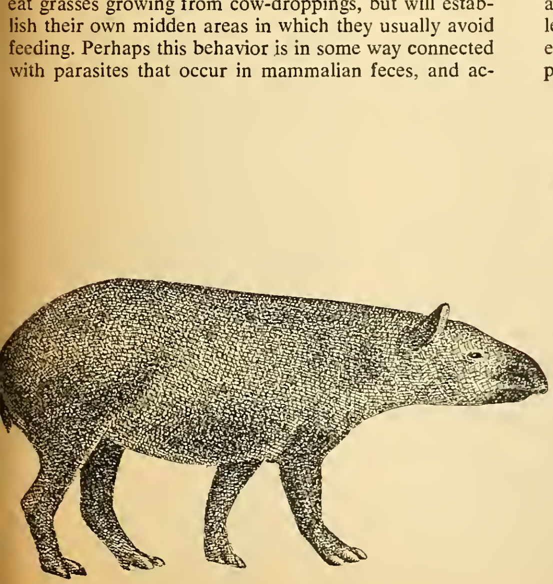
with their families for years. The nature of the individual is often reflected in the length of time it takes for its offspring to reach maturity, and these facts are eventually reflected in the numbers of a given species that reach maturity. It has been recorded that a single buck deer and three does were given complete protection from natural enemies for a period of eleven years, and in that time the resulting herd numbered 250 animals—some of which had to be killed to ensure that an adequate food supply would be available for the remainder.

Some kinds of mammals require more living space than others. Rabbits, for example, may develop warrens, where the burrows crowd closely together. Under such conditions the little mammals can literally eat themselves — and their mammal associates — "out of house and home." Other mammals cannot tolerate such crowding. The pronghorn antelope, to name one species, fails to prosper on a circumscribed range; it is possible, although perhaps doubtful, that disease may play a part in the large territorial requirement of the pronghorn. Most mammals, in common with birds and other animals, possess an instinct for territorial defense, and will thus to some degree affect their numbers in a given area. The territory of such an individual mammal may vary greatly, being exceptionally large at the time a new mate is being sought and smaller during the time that the young are not able to move about in safety.

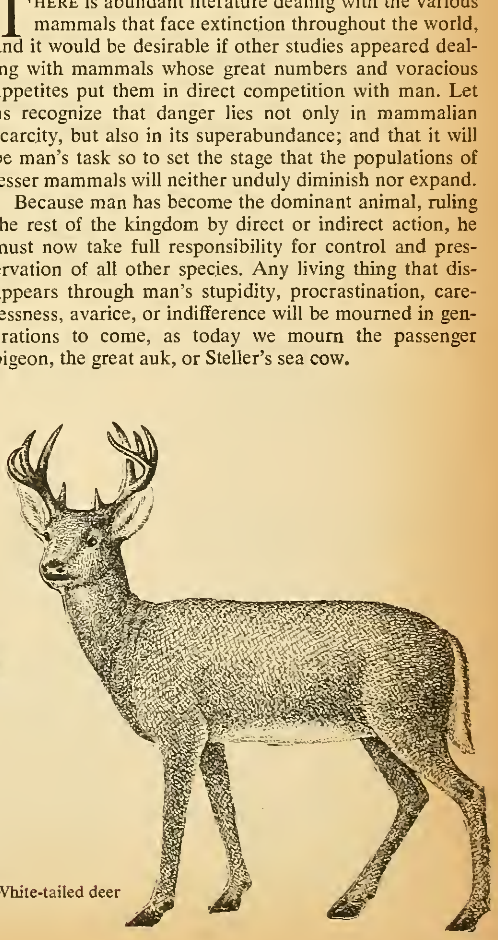
Disease is frequently an important factor in controlling the abundance of mammals, and some of the phenomena that may be presumed associated with its avoidance are most interesting. Cattle, for example, will seldom feed on grasses that grow from their own dung, but will feed on grasses whose growth has been stimulated by the manure of horses. The reverse is also true, in that horses will eat grasses growing from cow-droppings, but will establish their own midden areas in which they usually avoid feeding. Perhaps this behavior is in some way connected with parasites that occur in mammalian feces, and accords some protection to a mammal from its own parasites. It is quite likely that the greatest single influence on the abundance or scarcity of mammal life is human activity. There is little doubt that, were the human mammal to will it, most or all animal forms could be exterminated from the face of the earth —including man himself. Excessive hunting, the use of biological poisons, overcrowding, fire, disease, and the general upsetting of mammal ecologies have already accomplished much toward the extinction of many species. The interested reader may wish to explore the subject of threatened or vanishing mammal species further through reading of such publications as *Extinct and Vanishing Mammals of the Western Hemisphere,* by G. M. Allen, published in 1942 as Special Publication #11 of the American Committee for International Wildlife Protection, headquarters of which are in Washington, D.C.; or Special Publication #12, written by Francis Harper and entitled *Extinct and Vanishing Mammals of the Old World*. This volume was brought out in 1945.

THERE is abundant literature dealing with the various mammals that face extinction throughout the world, and it would be desirable if other studies appeared dealing with mammals whose great numbers and voracious appetites put them in direct competition with man. Let us recognize that danger lies not only in mammalian scarcity, but also in its superabundance; and that it will be man's task so to set the stage that the populations of lesser mammals will neither unduly diminish nor expand.

Because man has become the dominant animal, ruling the rest of the kingdom by direct or indirect action, he must now take full responsibility for control and preservation of all other species. Any living thing that disappears through man's stupidity, procrastination, carelessness, avarice, or indifference will be mourned in generations to come, as today we mourn the passenger pigeon, the great auk, or Steller's sea cow.



Tapir



White-tailed deer

	DESCRIPTION	DIET
DUCK-BILLED PLATYPUS *Ornithorhynchus anatinus* Order Monotremata	About 2 feet long. Male larger than female. Slender body, leathery, duck-billed snout, broad feet modified for swimming have five strong claws. Fur dark brown above, lighter beneath. Tail flattened. Semiaquatic. Eyes and ears closed by fold of fur when diving.	Eats aquatic insects, their larvae, worms, crustaceans, mollusks, aquatic vegetation. Food is gathered at evening, night, and dawn. In captivity it will accept earthworms, frogs, and coddled eggs, and it is not unusual for it to eat half its own weight every day.
VIRGINIA OPOSSUM *Didelphis marsupialis* Order Marsupialia	Females to 3 feet long including tail to 13 inches. Weight to 14 pounds. Males smaller. White face; naked, scaly, prehensile tail; black feet, each foot 5-toed, first rear toe opposable; grayish-white fur; black, naked ears. Mainly nocturnal. Are fine climbers.	Omnivorous, feeding freely on fruits, vegetables, poultry, reptiles, amphibians, mushrooms, insects. They may rob the nests of hole-dwelling birds and mammals. Eggs and persimmon fruits are highly favored. Often act as scavengers of carrion and other wastes.
BIG SHORT-TAILED SHREW OR MOLE SHREW *Blarina brevicauda* Order Insectivora	Large shrew, length to 6 inches with 1-inch tail. Weight to 1 ounce. Sexes about same size. Very small ears. Eyes tiny, see only light and dark. Nose pointed. Fur short and soft, silver-gray in North, darker in West and South. Both sexes have scent glands.	Food primarily insects, small mollusks, earthworms, spiders, salamanders, mice, carrion, nuts, fruit. Saliva contains substance causing bite to be painful, although not dangerous, to humans. Snails and worms paralyzed by poison may be stored for future eating. Has huge appetite in proportion to size.
LITTLE BROWN BAT *Myotis lucifugus* Order Chiroptera	One of 5 species of *Myotis* in N.A. Usually to 4½ inches long, including 1-inch tail. Weight from 1/7 to 1/3 ounce. Forearm has digits connected by flight membrane. Ears, if laid forward, reach to nostril. Color varies, according to range, from dark brown to pale tan.	Eats insects taken in flight, assisted by "sonar" sounds issued at the rate of up to 60 pulses per second, each pulse containing waves of 40 to 80 kilocycles in frequency, on the average. These emanations make it possible for bat to avoid striking objects, and to locate food.
MAN *Homo sapiens* Order Primates	Most abundant, successful, and intelligent of all primates. Walks erect. Eyesight good. Hearing average. Sense of smell poor. Taste glands well developed. Size and weight extremely variable, according to range, genetic variations, and the available food supply.	Omnivorous, food including other mammals, fish, a wide variety of herbaceous plants, nuts, fruits. Can develop, cultivate, and improve own food sources. Despite this ability, some ½ of population is either starving or suffering from a degree of malnutrition.
PANCOLIN OR SCALY ANTEATER *Manis pentadactyla* Order Pholidota	Heavy-bodied animal, whose body and tail are covered with large, overlapping, hard scales, between which grow coarse hairs. Length to 3 feet, half of which is tail. Legs short and strong. Claws heavy. Head small and tapered. Ears small. Mouth is toothless. Nocturnal.	Eat ants and termites, captured on extremely long, wormlike tongue, which is coated with saliva from greatly enlarged salivary glands. Dig into anthills and termite mounds to reach tunnels. Valves on ears and nose exclude insects. Can press scales together, killing insects crawling between them.
NINE-BANDED ARMADILLO *Dasypus novemcinctus* Order Edentata	Length to 32 inches, including tail 14 to 15 inches long. Weight to 17 pounds. Nine movable plates cover back and sides. Usually does not curl up for protection, hiding in brush or holes instead. Tail and head reasonably protected by scales. Ears and underparts naked. Strong claws aid swift digging.	Feeds largely on terrestrial insects and other arthropods such as tarantulas and scorpions, which it can locate surprisingly well by scent, even to 6 inches underground. Also feeds on bird's eggs. Has good sense of smell and of hearing, but poor eyesight. Usually is abroad only at dusk or at night.
EASTERN COTTONTAIL *Sylvilagus floridanus* Order Lagomorpha	Hind limbs longer than fore limbs. 4 incisors in upper jaw, 2 in lower. Length to 18 inches, including 2-inch fluffy tail. Females larger than males. Weight to 4 pounds. Ears 3 inches long. Eyes lateral. Fluffy fur, shed twice a year, varies in color, according to the animal's range, from brown to grayish brown.	Food primarily plants of almost any sort, including grass, garden vegetables, cattle forage, bark of orchard trees. Can be most destructive to crops. May eat own feces excreted during day. In many areas contend with man and hoofed animals for available plant supply.
NORWAY OR BROWN RAT *Rattus norvegicus* Order Rodentia	At 1 year, length to 19 inches, including long, slender, scaly tail to 8½ inches. Ears naked. Weight to 1½ pounds, but usually smaller. Fur coarse, grayish brown on the back, paler beneath. Sometimes blackish. Laboratory animals vary in color from white to black.	Food is almost any organic matter, plant or animal, including birds, grain, soap, garbage, eggs, carrion. May eat 1/3 of its weight daily. Damage to uneaten but fouled foods is enormous. Need quantities of water and will chew through pipes to reach it. Will gnaw through wiring, often causing fires.

REPRODUCTION	RANGE AND RELATIONSHIP	ECONOMY
Breeds in late winter or early spring. Lays 1 to 3 eggs, less than 1 inch long, in nest of damp vegetation 2 weeks to 1 month later. Eggs adhere together. Incubation period about 10 days. Young, poorly developed at birth, mature at 1 year. Life span to 10 years.	Found in eastern Australia and Tasmania, in almost any aquatic habitat from clear mountain streams to muddy, sluggish, coastal streams, ponds, and lakes. Its burrows in banks can be 15 to 60 feet long. Hibernation, or inactivity, occurs briefly in winter.	Platypus has virtually no natural enemies, with the possible exception of 1 or 2 snake species. Serious drought, water pollution, or failure of food supply could affect population. Although formerly it was widely sought for its otter-like pelt, animal is now protected.
To 18 honeybee-sized young born 11 to 13 days after mating, each ½ inch long. Twenty can fit in a teaspoon. Those not finding teats die outside pouch. Attached to nipples for 70 days, suckle for month more. Independent at 3 months after birth. Females breed at 1 year. Life span about 2 years in wild.	Common in wooded areas, or in orchards and other woods near centers of human habitation. Usually inactive in cold spells. Found New York to Colorado, south into South America, and in California and Washington, where introduced and established. Range spreading to north; numbers increasing.	Hardiness, variety of diet, fecundity, and general availability of adequate food supply guarantees survival and expanding population in spite of man's predation, some value of pelt as a fur, and some edibility of flesh. Feigning death may aid in survival, as "dead" animal is unattractive to many predators.
Tiny, pink, wrinkled young number 3 to 9, born in hidden nest. Length about 1-1/5 inches at 1 day and 3-4/5 inches by 3 weeks. Nursing stops in 3 to 4 weeks when length about ½ adult size. Several litters yearly. Mature at 6 months; probably dead at 30 months.	Ranges through eastern half of the United States and southeastern Canada, in fields, orchards, woodlands, and sometimes in buildings. May live in granaries and may eat both plant and animal matter. Signs are tunnels under leaf mold, in decaying logs, or in snow. Musky odor is noticeable in spring.	Short life span and inroads of its numerous enemies, including cats, dogs, owls, snakes, weasels, and other small predators, keep population in check. Is valuable to gardeners as a destroyer of mice and of insect pests. Tunnels they dig in forest floor or field litter aid in the formation of the soil.
Mating occurs in autumn, but sperm is stored by female until spring, when fertilization takes place followed by gestation of about 50 days. Often also breed in spring. Usually only a single young, weighing about 1/20-ounce at birth; about once in 100 births, twins are born. Flight begins at 3 weeks.	*M. lucifugus* ranges over most of the United States and much of Canada. Other species are more localized. Each has its own flight pattern. Females roost gregariously in summer, males usually solitary. Most *Myotis* migrate to caves in local hibernation patterns.	*Myotis* have few enemies, so life expectancy can be to 10 years or more. They are of value to man in the vast numbers of insects they eat while on their usually nocturnal flights. Can be nuisance in houses or barns because of unpleasant, musty odor and droppings.
Present world population of approximately 3 billion, increasing at a rate that could double the number of people in 40 years, is due to many factors, including improved health care and ingenuity in environmental control. As result, present arable land may be unable to produce sufficient food.	Range is virtually anywhere on earth's surface. Has ventured into seas and outside earth's atmosphere. Intelligence has allowed man to become world's dominant animal. Relationships with others of own kind show a history of great variability and inconsistency.	Only serious "predators" are other men. Man's control of own environment has permitted, in many cases, devastation of great areas, waste of natural resources, disregard for future generations. With extremely careful management, species may be preserved.
Female bears single young (more rarely 2) from January to March. Young stays with mother for a considerable length of time. It may be carried by clinging to mother's back or tail. For protection, adult may roll up with the young curled inside body. Scales are soft at birth, but harden soon after.	*M. pentadactyla* occurs in India and Ceylon. Related species are found in Borneo, Java, Formosa, South China, and Burma in Asia; other species are indigenous to Africa south of the Sahara. Some pangolins are arboreal. *M. pentadactyla* is largely terrestrial.	Pangolins are of little economic importance, as insects do not constitute any threat in areas animals inhabit. Its burrowing may be a nuisance locally. Are regarded as palatable, and are sought for food in certain areas. Scales used for ornaments and charms. Preyed on by various carnivores, including man.
Breeds commonly July through August, with fertilization delayed. Embryos begin to grow in November. Develop in about 120 days. Identical young, usually 4 of same size, developed from 1 fertilized egg. Eyes are open at birth. Plates of "armor" not completely developed and hardened until adulthood.	Ranges from S.E. New Mexico through Louisiana and S. Texas into South America. Found from sea level to 10,000-foot elevations where soil is suitable for burrowing and food is available. Can swim well by swallowing air to inflate itself, or can walk under water for brief periods.	Armadillos are extending their range and in many places increasing their numbers, and are not in danger of extinction in most areas, despite fact that meat is excellent eating. They submit to captivity and may do well on horse meat and dog food. Consumption of destructive insects is beneficial.
Breed 4 or more times a year, according to the weather conditions. 2 to 8 young, each weighing to ¾ ounce, born naked and helpless in fur-lined nest. Gestation period is 28-40 days. Young nurse for about 2 weeks, then leave nest. Females defend territory in breeding season.	Normal range of *S. floridanus* in North America is mostly south of Canadian border, east of Wyoming, and south into Mexico. Prospers on borders between open fields and woodlands or where food supply and sufficient protective cover are available. Lagomorphs have a nearly world-wide distribution.	Efficient predators include man, foxes, weasels, coyotes, hawks, owls, and dogs. May die of tularemia, which may be fatal to men who handle the dead rabbits. Millions are shot annually, but harvesting is relatively ineffective. Local overpopulation is serious problem. Are valued as pets, food, fur bearers.
Norway rats in wild may produce 6 litters of 1 to 15 young a year, and be old at 3 years. Females breed at 4 months and, in laboratory, cease breeding at 18 to 24 months. Young, born 22 days after breeding, are blind, naked, helpless, and weigh about 1/5 ounce. Eyes are open in 14 to 17 days.	*R. norvegicus*, introduced from Europe, is found nearly everywhere man is found, although temperature of —40°F. is critically low, and 104°F. is critically high. Can live in buildings or out; home range varies considerably according to available food supplies and number of other rats in same area.	Of danger to man in transmission of bubonic plague, typhus, and many other diseases carried by its fleas. Destruction costs man untold millions of dollars yearly. Laboratory animals, however, are of tremendous value to science in the investigation of many diseases.

	DESCRIPTION	DIET
GRAY WHALE *Eschrichtius glaucus* Order Cetacea	Length to 50 feet. Weight to 20 tons. Females longer than males. Color a mottled gray, but individuals range from light gray to black. Has small humps on back, but no dorsal fin. 2 to 3 grooves, 6 feet long and about 15 inches apart, on each side of throat. Has whalebone, or baleen, in mouth.	Tiny marine animals, strained from sea water through baleen, make up food of this whale and such species as finback, humpback, blue, and right whales, while related sperm whale and dolphins — including narwhals and killer whales — are toothed and prey on larger animals.
COLLIE *Canis familiaris* Order Carnivora	Males 22 to 24 inches at shoulder, female slightly smaller. Weight from 50 to 60 pounds. Slender, tapering head, clear eyes, arched brows. Deep, moderately wide chest, sloping shoulders. Long, heavy coats are black, tan, and white in various combinations, with white collar frill.	Like earliest man, to whom dog was probably a companion, animal is basically carnivorous. Domestication has led to concern about diet, and today's pets are also fed vegetables, eggs, and milk to fill nutritive needs and to affect cleanliness and odor in a way that equips them to live with man.
NORTHERN FUR SEAL *Callorhinus ursinus* Order Pinnipedia	Bulls to 7 feet long; weight to over 600 pounds. Cows smaller. Adult bulls dark gray to brown above, usually gray on shoulders. Cows grayish brown. Mouth, teeth, and jaws developed for grasping and tearing. Hind limbs can turn forward to support body weight. Voice a roar or bark.	Food is entirely flesh, including some 30 kinds of marine organisms. Have been known to swallow stones. Much feeding is done at night, and most animals eat about 1/15 of their weight daily. Harem bulls do not eat during breeding season, when they live off subcutaneous blubber.
AARDVARK *Orycteropus afer* Order Tubulidentata	Short-legged, thick-tailed, piglike mammals. Length to 6 feet, including the 2-foot tail. Weight to 140 pounds. Color, yellowish to brown-gray. Tip of tongue highly tactile. Forefeet 4-toed, hind feed 5-toed. Claws resemble both nail and hoof, and are adapted for swift digging.	In the wild, feed almost wholly on ants, termites, or sometimes on beetle larvae, or other insects. Powerful legs and strong claws are capable of opening hard-packed anthills or burrowing into termite colonies. Insects gathered on sticky tongues. Use feeding area to rest, as are immune to insects.
INDIAN ELEPHANT *Elephas maximus* Order Proboscidea	Size, massive. Weight of males to 8,000 pounds, smaller than African species. Color grayish. Ears large. Nose extended into flexible proboscis with nostrils at end, and finger-like projection at tip. Legs pillar-like. Skin thick and thinly haired. Incisors continue to grow, are tusklike, in upper jaw only.	Elephants are strictly vegetarians, devouring leaves, fruit, bamboo shoots, grass. May eat ½ ton of forage daily. Feed actively most of day. May push down trees as they feed. Rolling or hilly forests and areas of bamboo and tall grass are preferred browsing sites. Travel in herds of from 30 to 50.
HYRAX *Procavia capensis* Order Hyracoidea	Like tailless rabbits in appearance, with small ears and short, sturdy legs. To 22 inches long and to 9½ pounds. Fur thick; eyes small; sight and hearing good. Toes have hooflike nails. Front feet and, to some degree, hind feet have pads capable of clinging to smooth tree trunks or rocks.	Food is herbaceous, including leaves, grasses, bark. In captivity may eat bread, vegetables, and sugar. Although jaws are worked as if chewing a cud, are not ruminants. Feed in the daytime or evening, spending much of remaining time in rocky crevices where they are safe from their many predators.
SEA COW OR MANATEE *Trichechus manatus* Order Sirenia	Large aquatic animal to 12 feet long and to 1,300 pounds in weight. Some sex differences in size, with male larger. Color lead-gray. Short bristles cover body. Fore limbs are flippers. No rear limbs; flat, whalelike tail. Head and eyes small, upper lip overhangs the lower.	Food is exclusively plants growing under water or along shores. Taste is well developed, and they will select green, but reject brown, seaweed. Upper lip maneuvers food into mouth. Nostrils have valves permitting animals to feed under water, where they may remain submerged for 15 minutes.
TAPIR *Tapirus terrestris* Order Perissodactyla	Heavy-bodied animal with short, stout legs. Tail short and thick. Feet hoofed, with middle digit longer than others. Skin thick. Brownish to grayish hair smooth and sparse. Height at shoulder to over 3 feet. Weight to 500 pounds. Fine swimmers. Nocturnal. Upper lip elongated into proboscis.	Tapirs both browse and graze, using broad, sharp incisors, and extremely mobile lips to eat low-growing plants, twigs, the foliage of various kinds of trees and shrubs, fruit, and grass. When the opportunity presents itself, will eat cultivated crops.
WHITE-TAILED DEER *Odocoileus virginianus* Order Artiodactyla	Shoulder height to 4 feet; length to 6 feet; tail to 11 inches. Bucks, which can weigh to 300 pounds, have antlers that are shed yearly. Color, reddish in summer, grayish in winter, white beneath. Fawns white-spotted. When frightened, raises tail, snorts, and leaps in 10- to 20-foot bounds.	Feed on many plants, including aquatic varieties, on mushrooms, nuts, grass, leaves, grain crops, truck gardens. In winter browses on deciduous twigs, on evergreens and lichens. Heavy snow that covers vegetation and makes movement difficult presents hazards.

REPRODUCTION	RANGE AND RELATIONSHIP	ECONOMY
In January or February, about 1 year after mating, single young about 16 feet or longer is born in quiet cove in shallow water. Nurses for 6 months, when it reaches 25 feet in length. Sexual maturity may be reached in 2 years. Females probably breed only in alternate years.	Found in Arctic Ocean in summer. In winter migrates down U.S. Pacific shores to Baja California in Mexico when breeding takes place. Some also in northwest Pacific. Ranges in shallow waters where small invertebrates abound. May gather in groups.	In 1853, population estimated at between 30 and 40 thousand. Almost extinct in 1925, it is now rigidly protected internationally, and population is about 5,000. During migration—the longest of any mammal—thousands of spectators gather to watch as whales pass San Diego, California.
Collie litters are usually large—from 9 to 10 puppies being born after 60 to 65 days gestation. Eyes open in from 9 days to 2 weeks. Usually are sexually mature at 8 months. Can have 2 litters yearly. Longevity is mainly dependent on care, and large dogs are, in general, not as long-lived as small ones.	Like other domestic dogs, collie ranges wherever man wants to have an intelligent, courageous pet or work dog. Origin of this breed is unknown. Made show debut in England in 1860. Became very popular in the United States 20 years later. Good with children.	From earliest times, *C. familiaris,* which is considered to be one species, although number of breeds is enormous, has been man's companion, protector, and hunting aid. Collie is still shepherd's helper in Scotland, northern England, and Wales, where a dog can do field work of 12 men.
Bulls establish home territory and defend harem of up to 40 cows. Breed in summer and fall. Cows give birth to 11-pound, shiny black pup 8 to 12 months after mating. Learn to swim at 6 to 8 weeks; nurse until about 4 months, when they take to the water where they spend most of their lives.	*C. ursinus* travels in oceans and, during breeding season, comes ashore in U.S. on the Pribilof Islands in the Bering Sea, rarely elsewhere in Alaska. During migration, the longest of any member of this order, is dispersed over North Pacific, Bering Sea, Sea of Japan, Sea of Okhotsk, to San Diego.	Once threatened by extinction, the seal is now internationally protected, and the Pribilof summer population is estimated at 600,000 newborn and twice that many adults. About half of young die each year from storms, starvation, crowding, and predation. Enemies include sharks, walrus and parasites.
From May to July usually single young is born, more heavily haired than sparsely haired adults. When about 2 weeks of age, may follow mother in nocturnal food forays. Home burrows usually slope 4 or 5 feet into ground, then may run parallel to the surface for some distance.	Aardvarks range through Africa, south of the Sahara Desert, from Senegal, central Sudan, and Abyssinia, south to Cape of Good Hope, on open plains, savannas, and clearings where many termites and anthills exist. Occasionally found in brush or, rarely, in forests.	Flesh is high in fat, and is prized by many, but it is not regarded as a game animal. In some areas, aardvarks are considered a nuisance to horsemen and farmers, as burrows make riding hazardous and can cause crop damage. Predators are most large flesh eaters.
Single or, rarely, 2 young, weighing to 200 pounds at birth and standing to 3 feet high at shoulder, are born to a cow about 18 to 24 months after mating. Shed milk tusks at about 5 months, suckle for 2 years, and reach puberty in about 14 years. Female may bear 5 calves in life. Life span to 60 years.	Indian elephants occur south of Himalayas, in India, Ceylon, Assam, Burma, Thailand, S. Vietnam, Malay States, and Sumatra. Introduced in Borneo, where they aid in teakwood forestry, hauling lumber to waterways to be floated to mills often located many miles downstream.	Economically is important as a work animal and beast of burden. Indian elephants are not sought as game animals as much as the African species. Ivory of tusks is also important to economy of countries it inhabits. Man is almost its only natural enemy.
Young, born about 7½ months after breeding, usually number 2 or 3 (may be 1 to 6). At birth they are fully haired and their eyes are open. They reach puberty at 2 years. In captivity they have been known to live to 7 years. During breeding season, unpleasant odor is secreted.	*P. capensis,* like other terrestrial species of hyrax, lives in cliffs, scrub, or rarely in grasslands, from sea level to 15,000 feet, in colonies of from 6 to 50. Various species are found throughout Africa and the Arabian Peninsula, Syria, and Israel. The related arboreal species are nocturnal.	Natural enemies are primarily eagles and large members of the cat family. Because of dietary habits have become pests in some agricultural areas. Arboreal species of hyrax tame easily. Terrestrial species, including *P. capensis,* are not so gentle. Despite low reproductive rate, seem well established.
Breeding begins when manatee is 3 to 4 years old. Gestation period not definitely known, but probably over 5 months. Single calf born under water; weight to 40 pounds, length to 3 feet. Calf probably stays with mother for about 2 years. Breeds any season.	Range is coast of southern Atlantic states, around Florida and Gulf coast, the Caribbean Islands, down eastern shores of Mexico. Often travel in small herds; migrate slightly to north during summer. Other species are found on South American and African coasts.	Manatees are often shot illegally, or are killed by pollution in shallow waters. Although protected, stringent enforcement of laws needed. (Steller's sea cows became extinct about 1768 because of excessive hunting.) Flesh is delicious, and oil is valued in cooking.
After a gestation period of from 392 to 405 days, 1 or, occasionally, 2 young are born. Unlike solid-colored adults, young have whitish spots and longitudinal stripes on dark hair. When about 6 months old, adult coloration has developed, at about which time young may permanently leave parents.	*T. terrestris* ranges from southern Mexico to southern Brazil. They prefer grassy swamps, savannas, dense jungles, and forested hills near water, from sea level to high in mountains. Other species are found in Burma, Thailand, Indo-China, Malay States, Sumatra.	Activities center near water, where animals can feed, bathe, and escape from external parasites and predators. Jaguars, perhaps pumas, and man are the principal enemies of the tapirs. They are shy animals that may occasionally cause some local damage to gardens in isolated jungle clearings.
One buck may breed with several does in November, in North, to January in South. Usually 2 and rarely 3 or 4 fawns are born some 6½ months later, each weighing 3 to 5 pounds. Nurse about 4 days before grazing begins. Weaned at 4 to 6 weeks. Most does breed at 1 year.	Range from Washington, Oregon, and southern Canada east to Atlantic, south into South America. Prefer water to be accessible. Once near extinction in certain areas, now increased to nuisance point in many places. Home range only about a mile in radius.	Legal protection and reduction in numbers of natural predators has allowed deer to increase at such a rate that they create economic problems for farmers and foresters in many areas. Although widely hunted legally, herd management remains vital problem for both man and animals.

nature IN THE SCHOOL

In scanning the pages of our daily newspapers, one is quickly aware of the pressures that have been exerted on the schools of our nation by the tremendous "explosion" of our human population. This phenomenal increase in human mammals has forcibly brought the subject of general animal abundance into the classroom itself, so that a study of it seems worth while. The chart section that accompanies this educational insert briefly considers the effect of mammal abundance on representatives of eighteen living mammal groups, not including the flying lemurs of the Order Dermoptera.

Members of each group mentioned in the chart have certain similarities in their basic anatomies, so that if a member of one group is well understood, the essential qualities of the other members may be estimated.

The student should familiarize himself, through observation and reference to appropriate texts, with the reproductive capacities of as many mammals as he can. How many young are there in the litters of a particular mammal? How many litters are produced in a season? What is the length of the mammal's reproductive life? There is a tremendous variation in these factors among different creatures. For example, a shrew's life span may be only two years or so; in the elephant, the gestation period alone lasts from 18 to 22 months, or nearly as long as the shrew's entire lifetime. In the opossum, a dozen young may be suckled by the female only two weeks after mating, and the youngsters are wholly independent at 16 weeks; the elephant may produce only four or five young during a whole lifetime. The significant data of the mammalian reproductive story are available in a number of current texts and fieldbooks.

The student should familiarize himself with the reasons underlying the game law provisions of his state. Local hunting regulations may forbid the killing of one or the other sex of certain mammals, or it may allow only the killing of animals of certain age groups. Why should this be so? The student should also be familiar with the reasons behind the complete protection of certain species; those whose numbers are either at a dangerously low level or are composed of a proportionately high percentage of older individuals.

Game management practices that are directed toward influencing the total population of any given mammal must take into account a number of different factors—the mammal's value, living or dead; the value of its pelt at different seasons of the year; the need for managing its food supply; the importance, if any, of the part the creature plays in the food cycles of its associates. The snowshoe rabbit, to name an example under the last category, is remarkable for its abundance cycles, and the rise and fall in its numbers is reflected in a corresponding rise and fall in the numbers of its archenemy, the lynx.

The availability of nesting sites or dens also may account for the abundance or scarcity of a mammal.

Human foibles, too, may affect the total population of a mammal species at a given time. When college students favor blue jeans instead of coonskin coats, the raccoon population is likely to rise, other factors being equal. At one time, the fur of a certain species of monkey was considered fashionable, and the species bearing the fur was nearly exterminated in the name of fashion.

The little mammal known as the copyu, or nutria, was at one time listed as in danger of extinction. In 1952, the nutria was introduced into the southern part of the United States, and since that time has multiplied so greatly as to become a pest and a menace to native animal species. Ten years after its introduction, some fifty thousand nutria were taken by trappers in the lower Mississippi Delta region, and their abundant presence had affected the prosperity of such wild animals as wild ducks and muskrats, to say nothing of farmers in the area. The introduction of wild mammals—and plants, insects, and birds, for that matter—into new areas is likely to have a serious impact on the native fauna and flora. Not all introductions are successful, but those exotics that flourish, often do so both explosively and disastrously.

The change in mammal abundance is often a local phenomenon rather than one of general significance. In my home locality, the white-tailed deer is now abundant, although several decades ago it was not to be found. Opossums have made their appearance during the course of the same time span. Gray squirrels have returned. In the last decade I have seen a porcupine in its free and wild condition within a hundred yards of my home, and coyotes have been seen within a mile. The raccoons that rattle my garbage cans nightly in season announce the coming of spring. A few years ago the discovery of a raccoon in my locality was an event that warranted at least some mention in the local paper.

The student, through his own research supplemented with information gathered from older relatives and friends, might try to investigate the changes in mammal populations that have taken place in his own vicinity. The local newspapers of "earlier days" may sometimes reveal valuable information toward this end; old textbooks and other literature may furnish valuable clues.

I always have on my desk a list of mammals indigenous to my local watershed—a list that was prepared and published fifty-two years ago. It reports a male opossum being captured fifty-eight years ago, an event that would certainly not be news today. It makes no mention, however, of beaver, black bear, porcupines, or coyotes, which have been seen in the vicinity during recent years. It reports a Canada lynx taken fifty-six years ago, but does not mention the presence of bobcats, which have been reported in the area in later times.

In summary, there is often a temptation to dwell on the "good old days" when we discuss the abundance of mammals, and to ignore the fact that the present is not wholly bad. In some respects it actually may be better than the past. Most important, however, is the recognition that what we do in the present will determine the course of the future. We know how to save and control our present mammal populations, both wild and domestic, and we should probably not spend much time regretting the fact that wild buffalo no longer roam our plains. We should rather plan constructively in order to protect and preserve the species that exist today.

Fungus ant workers, in this species only about 1.8 mm. in length, move over their garden, discarding unwanted parts, and depositing saliva and feces, which aid in fungus growth. Long antennae help in the process by locating foreign matter.

Insect Gardeners

New World ants sustain gigantic colonies on leaf-grown fungus

By Neal A. Weber

Fungus-growing ants—leafcutters that rival man in their skill as gardeners—are found only in the New World, and appear to have developed their distinctive "cultivation" of special sorts of fungus long ago in tropical South America. From that area, apparently, they spread south into temperate Argentina and north as far as New Jersey in the United States. They are also found in our Gulf States and west to California.

The two genera that contain the largest individuals are *Atta* and *Acromyrmex*, leafcutters familiar to most residents of tropical America. One of the largest *Atta* species, *A. cephalotes*, demonstrates the extensive polymorphism — that is, the great variation in size of the ants in one colony — that is characteristic of these tropical genera. The female has a large head, compound eyes, and three simple eyes (ocelli) in the middle of her forehead. The male also has three simple eyes, but a much smaller head and weak mandibles. The soldier caste has a very large head to accommodate the great muscles that close the mandibles. The soldiers often have

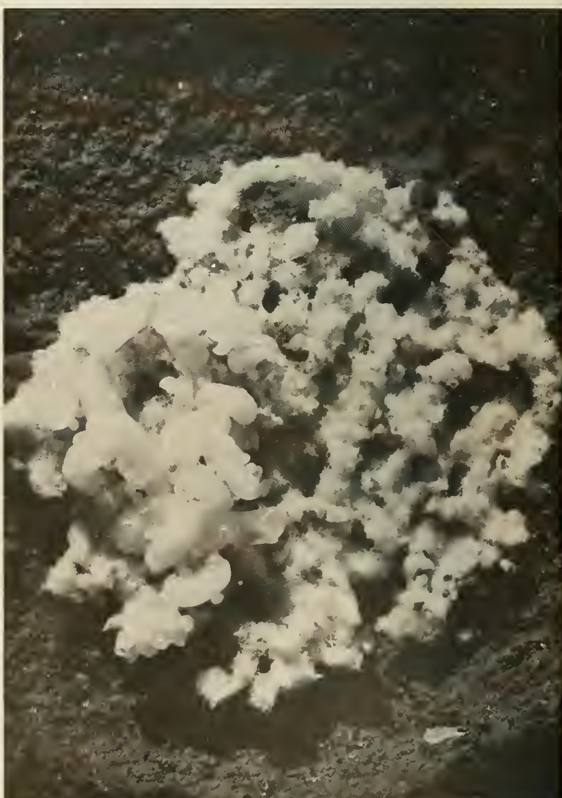
EIGHT-DAY-OLD EGGS are of the South American tropical species, *Atta sexdens.*

a double simple eye in the middle of the head. This is of particular interest to students who follow the development of insect eyes, for it suggests that this middle simple eye was originally a pair that, in the course of evolution, fused together. Below the soldier in size is a great range of workers. The smallest workers ordinarily stay in the fungus gardens of the nest all of the time. The larger workers range far from the nest, on populous trails, cutting down green leaves of trees and bringing them back to serve as garden material.

LONG, spindly legs are a characteristic of the fungus-growers in general. Each leg terminates in a pair of hooks with which the ants readily climb trees or anchor themselves as they cut out sections of green leaves. At the end of the second long segment of each foreleg is a comb, which plays an important role in keeping the ants clean. The insects' antennae bear sensitive chemical receptors at their tips. By delicately playing these tips over the growths, the ants continually check on the condition of their gardens and on the fungi therein.

The form of a mature fungus garden varies among the different genera of gardening ants. It is generally a sort of honeycomb: the loose particles of plant materials that form the substrate are held together by the threads of the fungus. Among the large leafcutters, such a garden may be ten inches in diameter. In *Atta,* the garden is globular in shape, except where flattened at the base. The tops and sides of the gardens are always surrounded by a space, so that they do not touch the earth in which they are entombed. The garden starts on a rootlet left standing in the underground space excavated by

AT TWENTY DAYS, eggs are enmeshed in fungus cluster. In some areas, people collect and eat the egg-filled female ants.



TWO SIZES OF EGGS are visible at fifty days. As the eggs mature, the fungus garden, kept moist and warm, also grows.

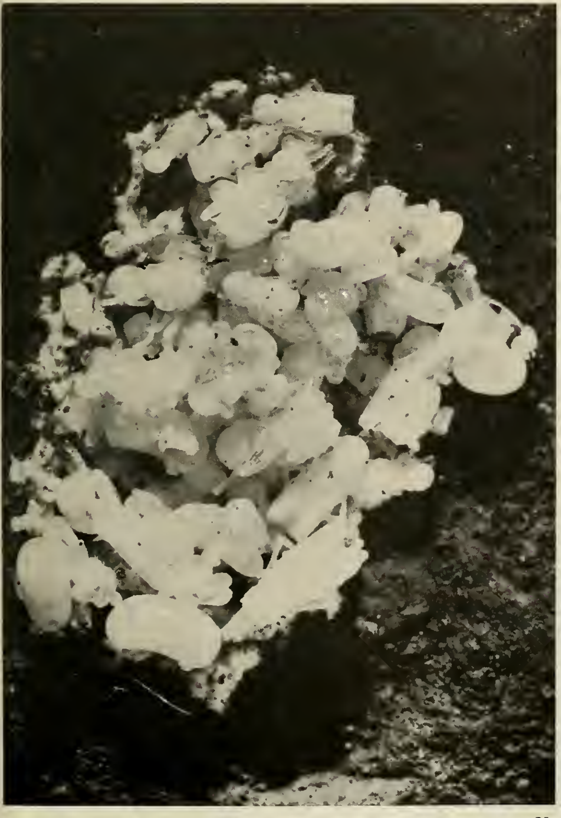
Dr. Weber, of Swarthmore College's biology department, is now on leave for two years, in order to serve as the Science Officer, United States Embassy, Buenos Aires, Argentina.

the ants, and is later expanded, with support being provided by other roots that the ants leave in the enlarging excavation. The ants frequently leave stones in place at the bottom of the garden, removing the soil around them, to provide additional support. There is, in consequence, excellent drainage. The gardens are further protected by having the access tunnels enter near the bottom of the cavity in which they grow.

The cells of the garden's "honeycomb" necessarily vary in dimensions according to the size of the ants. The various species of *Apterostigma*, for instance, have gardens composed not of leaf material but of pellets of insect droppings (often those of the wood-boring beetle or caterpillar) and of small pieces of wood. These are held loosely together by short filaments of fungus. In some species, the whole loose mass of cells is then enclosed with a veil of the finest and most delicate character, also fungoid. I was long puzzled by this, wondering if the veil was formed in some way through the agency of the ants, or if it was a natural growth. Finally, I found the answer in pure fungus cultures grown on sterile grass stems in humid flasks. The fungus would first grow out at right angles for one-quarter inch from the upright grass stems, then intertwine at the outside edges to form the same kind of sheath or veil seen in the *Apterostigma* gardens. When touched with a sterile needle, the veil would instantly collapse. The ants, however, have no difficulty in walking about on the pellets inside the veil without disturbing it in any way.

Laboratory cultures of the fungi "raised" by gardener ants may be easily overwhelmed by such common soil contaminants as *Penicillium* and *Aspergillus*. In the garden, however, only the one ant fungus thrives. How do the ants manage this? In an attempt to account for the purity of the ant fungus, I carried out an experiment using sterile Petri dishes filled with nutrient agar. Fresh samples of gardens were placed beside some dishes, the covers were tilted at one side, and bits of the garden were transferred to the agar with sterile forceps. In other dishes, a cluster of ants was included on the transferred piece of fungus garden.

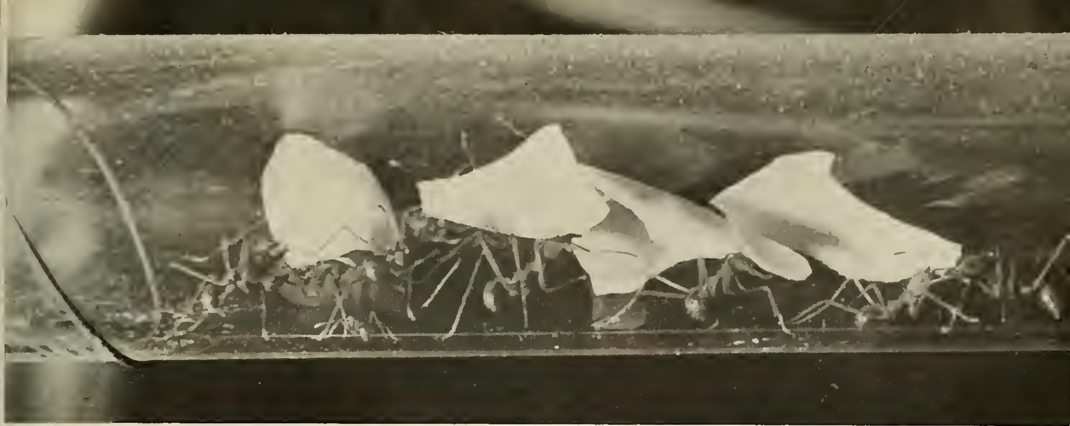
Lifting of the covers, even momentarily, introduced contaminating fungi and bacteria, and these contami-



Maturing pupae can be seen at fifty-six days. These are from the small eggs: larger eggs have been eaten by females.

Nearly grown worker ants now begin to emerge. They vary greatly in size — a situation that is known as polymorphism.

TRINIDAD LEAFCUTTERS dissect a fallen papaya. Here, the green rind has already been removed, and the pulp is being transferred to garden. In this case, both fruit and leaves had been cut. Some species can defoliate a tree overnight.



Method of leaf transportation is demonstrated in glass tube, as worker ants move from the leaf source to the garden. As fungus develops around leaves, more food is produced for the growing colony, which in turn can provide more workers.

nants at once started to grow. Those pieces of garden that lacked ants to "care" for them remained normal less than a day before they started to deteriorate. Alien organisms soon overwhelmed them. When ants were included, the fungus gardens stayed healthy for a considerably longer time.

In the dishes, therefore, the ants obviously proceeded as they do in their natural habitat. They moved over the garden, licking the fungus, feeling every bit with the tips of their antennae, discarding parts damaged in the transfer, and depositing their liquid encrement on the garden. Both saliva and feces, therefore, were regularly applied. Furthermore, they cut out pieces of the agar adjacent to the base of the garden and cast these some distance away. It was significant that such pieces, to which some saliva inevitably adhered, did not grow alien organisms as soon as did untreated agar. In time, some of the ants would excavate all of the agar in the immediate vicinity of the garden, leaving the fungus "honeycomb" undisturbed on the glass.

The single fungus-grower of the eastern United States—*T. septentrionalis*—has an extended distribution along the Atlantic coast in open, pine woods. The ants themselves are inconspicuous, and are best located by crescent-shaped mounds of sand at the nest entrance. The ants march out from the nest, go several inches away from the hole—in one direction, to start with—and then dump their loads of sand. The semicircular crater that forms has a distinctive character, and in the laboratory the same ants produce the same sort of crater if they have enough sand to dig in.

Early one September, while showing a French colleague a New Jersey Pine Barrens site of these northernmost fungus-growers, it was my good fortune to witness a colonizing flight of females. They left singly from several nearby nests, crawled up on grass or stems, and took flight up through the scattered pine trees. A few were captured and isolated singly in small glass tubes in the laboratory, where they developed gardens. It appeared that the females had carried bits of the "home" gardens in their mandibles, since when the developing, test tube gardens were first seen, they were far too big to have

Typical garden is suspended from roots in a clayey soil. Although structure varies among species, it is usually of this honeycomb shape, may reach ten inches in diameter, and is always surrounded by space separating it from the earth.

Huge queen of the species *Atta sexdens* is surrounded by workers of various sizes. This species shows considerable polymorphism, as it includes a soldier class. Queen has a large head, with two compound eyes and three simple eyes.

been concealed in the pocket off the mouth in which the ant regularly carries debris from its garden-grooming.

These females are marvelous creatures. The queen is responsible for continuing the ants from one generation to the next. Long ago, it was found that the queens among the big Brazilian *Atta* leave their parental nests bearing a bit of the "home" garden. Each queen then digs a hole in the ground, deposits the fragment of garden and manures it. The fungus grows rapidly in this moist, tropical cell, and the queen lays her eggs on the growing garden. In recent years, Dr. Mario Autuori, in Brazil, followed this early life of a colony and produced an excellent photographic record. He found that two kinds of eggs were laid. One is of the ordinary type, while the other is more globular, larger, and rich in yolk. The queen or her daughters eat the larger eggs, thereby gaining energy to build up the garden. Finally, after the first brood has matured, the ants break out to the surface of the soil and start bringing in bits of leaves needed to expand the fungus garden. Garden and colony now grow rapidly. The more the fungus grows, the more food there is for the developing brood, while the increased numbers of ants means that more leaves can be brought in for the garden.

It used to be thought that the queen degenerates into a mere egg-laying machine, but my experiments and observations show that this is far from the case, at least in the critical early stages. Instead of losing any of her behavioral capabilities when she starts producing eggs, she remains more efficient than the worker. When a queen and the sole surviving worker of a Panamanian colony of *Trachymyrmex* lost their garden, I gave them small cultures of fungi taken from other fungus-growers. Invariably, it was the queen who first perceived the culture as acceptable food, approached it, and started feeding. Finally, the two were placed in an observation nest, partly filled with clean, moist sand in which a hole had been punched with the eraser of a pencil. The queen quickly went to the fungus, tasted it, and then started cutting pieces and carrying them two inches away to the prepared shaft. She carefully placed these small pieces at one side of the shaft, about midway from top to bottom. All this time the worker followed her about, much as a puppy might follow its mother, going back and forth but without either cutting or carrying fungus. The queen continued to cut and transfer all of the fungus, built up a neat garden, then placed grains of moist sand over the top so that nothing more could be seen.

One of the most fascinating aspects of the gardening techniques of these insects is that, by using leaves — a widely available raw material, which, in itself, is not highly nutritive — the ants are capable of growing a product that supplies the dietary needs of huge communities of a highly complex social structure.

LONG, SPINDLY LEGS are characteristic of fungus-growing workers. Legs terminate in pair of hooks allowing ants to climb trees or anchor themselves while cutting leaves. It is possible for ants to chew half-moons from leather boots.


plane of the ecliptic
VENUS
MERCURY
celestial equator
Sun's position
one half hour

CELESTIAL EVENTS

A list of astronomical occurrences for the first half of 1962

By K. L. Franklin

JANUARY

January 2: Today the earth is at perihelion—nearest the sun for this year—91,400,000 miles away.

January 3: Early this morning, before dawn, the Quadrantid meteor shower will reach its peak. Under ideal conditions a single observer could see 40 meteors per hour. These will appear to radiate from a point in the northeast sky in the constellation of Boötes.

January 22: About 9:00 p.m., EST, watch the moon approach the brightest star—Regulus—in Leo. Northern and eastern observers will see an occultation.

FEBRUARY

February 4: A total eclipse of the sun will begin in Borneo at sunrise, move the length of New Guinea, and finally end off the coast of Lower California. Residents along the Pacific coast will see only a partial phase of the eclipse, which will begin about an hour before sunset.

All of the naked eye planets are now within 15° of the sun. At the time of the solar eclipse, even the moon will join the ensemble. This arrangement is rather unusual, and it leaves the entire night sky to the stars alone. Following is a list of distances and times of the planet's conjunctions with the sun. All fall within a two month period.

PLANET	DATE	MILES FROM EARTH
Mars	December 14, 1961	228 million
Saturn	January 22, 1962	1020 million
Venus	January 27, 1962	159 million
Mercury	February 5, 1962	61 million
Jupiter	February 8, 1962	560 million

February 19: Regulus will again be occulted by the moon. Watch from about 5:30 a.m., EST. Binoculars will aid in seeing the star near the nearly full moon.

Before this occultation is over, a penumbral eclipse of the moon will technically begin. By 8:04 a.m., EST, the south pole of the moon will have darkened to about half its usual brightness. Since the moon will have set by this time throughout the continental United States, only the faint beginnings of this eclipse may be observed.

MARCH

March 6: The moon is closest to the earth this month at nearly the same hour as new moon. Adding an increased lunar force to that of the sun, the combination will bring about a perigee spring tide of unusually wide range—the highest highs and lowest lows.

March 11: Aldebaran will be occulted by the moon this evening for observers in the western half of North America. Watch from 9:30 p.m., Pacific Standard Time.

March 20: Spring begins for the Northern Hemisphere at 9:30 p.m., EST, as the sun crosses the celestial equator on its return journey from the south.

March 31: The last quarter moon and Saturn will be very close in the morning sky. In the northeastern part of the United States, a short occultation is to be seen about sunrise. Use binoculars on the first magnitude planet.

APRIL

Some of the planets are becoming easier to observe, as the earth moves around the sun to join them in space. Early risers will notice Jupiter shining brightly in the southeast. Saturn, appearing to be a first magnitude star in Capricornus, is higher and farther to the south. Before the end of April, Mars—at + 1.4 magnitude—may be seen just before dawn in Pisces, low in the east.

April 20-24: A weak meteor shower—the Lyrids—will have its normal hourly rate of 15, for a lone observer, severely diminished by the bright moon.

April 28: This Sunday morning, 2:00 a.m. will become 3:00 a.m., EDT. Daylight Saving begins on this date for many parts of the country. "Spring ahead."

MAY

May 5: This night is the peak of the long meteor shower called the Eta Aquarids, when a single observer may see as many as 20 meteors per hour. A few meteors may be seen from the middle of April until the third week of May.

May 11: The moon and Regulus will be very near in the western sky. Western Canada will witness an occultation about midnight, Pacific Daylight Time.

May 13: Elusive Mercury is farthest east of the sun this season. Although much brighter two weeks ago than its present + 0.5 magnitude, it was lower in the sky at sunset. Venus is a little above and south of Mercury, a bright — 3.3 in magnitude. Look for Mercury tonight with binoculars and compare its movement with Venus for a few evenings. The illustration, *left*, helps locate the two planets.

JUNE

June 10: Within a few hours, the moon will be at first quarter and at the point farthest away from the earth. This combination will result in the very low apogee neap tides.

These apogee neap tides have the lowest highs and the highest lows, and hence extend through a very narrow range. Contrast this tidal range with the perigee spring tides of March 6, *above*.

June 20: The Southwest will see an occultation of Saturn. Watch from 10:30 p.m., Mountain Standard Time.

June 21: Summer begins in the Northern Hemisphere at 5:24 p.m., EDT. The nights will begin to get longer as the sun starts toward the winter solstice 184 days away.

Dr. Franklin of The American Museum – Hayden Planetarium prepares this summary each six months.

Drifting Gulls

Both age and the wind are factors in these birds' movements

By W. John Smith

THE HERRING GULL is a bird well known throughout most of North America. The adult is a large, white, and conspicuous bird, with a light-gray mantle and black wing-tips, spotted with white. When immature, the bird is brown-streaked and less striking. The species is particularly familiar to cottagers on northern lakes and along the eastern seaboard, but herring gulls are also found along the Mississippi and other rivers and, at least in their immature forms, even along the Gulf of Mexico. The birds are to be seen pacing beaches, flocking at garbage dumps and plowed fields, sitting on fishing wharves, and following ships or schools of herring. The herring gull has often been spoken of as a migratory bird and, indeed, many individual herring gulls accomplish considerable journeys. In fact, however, further study is necessary if their behavior is to be correctly defined.

Recently, I had the opportunity to plot some 1,143 recoveries of herring gulls, banded when still young on their nesting islands in Lakes Michigan and Huron by Mr. C.C. Ludwig and his two sons, of East Lansing, Michigan. The Ludwigs had banded 37,414 gulls between 1931 and 1957, and it seemed likely that the data derived from recoveries should present a clear pattern. This proved to be the case.

After fledging, the birds begin to disperse from the nesting islands. Some young herring gulls leave early, others leave later, and some scarcely leave the area at all. Sixty per cent of the young birds that were recovered had remained within 300 miles of the

PLOTTING ALL GULLS recovered during their first year—only small fraction of thousands banded by Ludwigs—reveals wide dispersal of these immature birds.

breeding colonies, as had nearly all of the older ones. What travel of any note that occurred among these herring gulls was largely confined to a portion of first-year birds, but this 40 per cent wandered widely. Beginning about December, many birds in this wide-wandering group start a southward movement that has been spoken of as a migration. It may be a long trip. Some few birds will reach Mexico, the West Indies, and very rarely, points still farther south. Since few of them remain in the south after their first winter, the ensuing northward return to home waters in the spring usually completes their movement.

THE direction the wide-wanderers fly is shown in recovery reports. Although at first there is little more than apparently erratic wandering about the lake shores and rivers near the colony, more and more birds are recovered east of the nesting islands as autumn wears on. They spread out along Lakes Erie and Ontario and into the region of the St. Lawrence River; then, as the severity of winter begins to be felt, those herring gulls that have reached the Gulf of St. Lawrence start south along the eastern coast of the United States. Some of the birds still on the Great Lakes find the inland waterways of the Mississippi system and follow these to the Gulf of Mexico, to winter over on the shores of Texas and Louisiana. The pattern is thus an irregular eastward movement of some birds, followed by a southward movement of most of these, as well as a move south by some birds that had stayed behind on the Great Lakes. Finally, a northward return occurs in the spring.

Because all these travels take place along coasts or rivers, it has often been suggested that the herring gulls follow waterways because they provide a source of food. This suggestion certainly seems valid, especially since most studies have shown that the species finds its food primarily in or near water. But the herring gull is omnivorous, taking everything from fish and carrion to earthworms, grasshoppers, and even blueberries. Since the bird is not restricted by necessity to waterways as sources of aquatic food, but could presumably travel overland, it is probable that other considerations also play a part in determining routes.

One such factor may be the herring gull's predilection for soaring—as opposed to flapping—flight. Gulls, like

ıny other soaring birds, follow the e of least resistance. They do not p when they can soar, and will often oceed from point to point by round-out routes, making use of the upcur-ıts of air needed to sustain a glide. ıey will even seem to "indulge" in ıring purely for soaring's sake: ob-vers in aircraft have identified her-ıg gulls at altitudes as high as 3,500 t, a behavior that probably cannot attributed to the search for food. dies of water, shores, and beaches, course, offer whole lanes of uprising lumns of air. Winds are deflected ɔm breaking waves, from dunes, ıffs, and banks, and thermal cur-ınts rise over hot sand. In late au-mn, the water—kept warm by its high ermal capacity—may be warmer an the air above it and will itself pro-ce thermal updrafts. If a herring ll is to travel, here are routes neatly ted to its form of flight.

If we compare the pattern of move-ent just described with the annual ttern of prevailing winds, we find interesting correlation. Broadly eaking, the prevailing winds blow ɔm the west over the Great Lakes d down the St. Lawrence River in e autumn, shifting in winter to blow wn the Mississippi and down the At-ıtic coast from the north or north-st. In spring, the prevailing winds e southerly up the Mississippi.

UCH a pattern, of course, does not describe every wind every day, or en nearly so, but neither does the avel picture describe the route of ch and every herring gull. Some de-wandering birds break the ideal ttern, moving to the north or to the est, but this is decidedly not the neral trend. There are, for exam-e, relatively few recoveries from ıke Superior. Yet this Great Lake is arcely remote from the breeding col-ıies, and if distance dispersal were ore erratic, there should be many ore recoveries from its shores. In-ed, the few most westerly recoveries the Ludwigs' birds come from the me of the spring return, rather than om the winter dispersal. The fact at these recoveries are from western ibutaries of the Mississippi suggests at each represents a "wrong turn" some southerly junction of waters. Thus, we have in the pattern of pre-ıiling winds another factor that may lp explain the correlation between rring gull dispersal routes and the

BETTER IMPRESSION of great distances traveled by young gulls is given, *above*, by isolating only those birds recovered in the second half of their first year.

SHARPLY CONTRASTING PATTERN is seen by mapping recoveries of all gulls over a year old. These show a concentration within 300 miles of original colonies.

geographical features of rivers and coasts. Let us envision the young gulls soaring aimlessly over the shores near their home colonies. These birds are affected, each to a greater or lesser degree, by the pressure of the winds—the prevailing winds in particular. Some young gulls are carried farther along main thermal lanes than are others, and eventually turn up on the Atlantic or on the Gulf of Mexico. In view of what is described above, their flight path is perhaps a case of drift.

Drift has recently attracted considerable attention as a major factor in bird migration. It has been suggested as a strong influence on the direction of flight. It has been shown that, in small birds at least, drift may even result in extensive loss of life. If we are to accept the assumption that drift is a factor in herring gull migration, two interesting hypotheses follow. The first is that winds mechanically or fortuitously push birds along. The second—and considerably more complicated—is that the stimulus of winds blowing in a certain direction releases a "drifting response" in some young birds and not in others.

In the second hypothesis, the drifting response would presumably be an inherited feature, one that natural selection would favor in years when a hard winter kills many young birds in the North. It would not be favored, however, in mild winters when the immature bird might stand a better chance of surviving in the North than if it made a long and dangerous journey. The fluctuation between hard and mild winters, then, could assure that birds with both genetic attributes would survive to make up the total breeding population and pass on their "drift" or "non-drift" characteristics to generations that face one or the other situation in their first year. To test either hypothesis, it is necessary to know whether the gulls move with the prevailing wind or independently of it. Once in drift or migration, the young birds presumably exercise choice about where they will stop. What is important for us to know is whether they *choose* winds of the correct direction from the very outset or not.

To say that a species travels by soaring with the wind, however, is not to say that it does or does not migrate. Each fall, thousands of broad-winged hawks pass over Hawk Mountain in Pennsylvania. The best flights—the

Dr. Smith, a research associate of the Harvard Biological Laboratories, is now in South America studying the New World flycatchers. This is his first appearance in Natural History.

days when the largest numbers of hawks are aloft—are characterized by the presence of northerly winds that directly assist the birds southward and also provide updrafts by deflection off the mountain slopes. These hawks are migrating, making an oriented movement that takes most of the population to Central and South America for the winter and that recurs with reasonable regularity. The case of the herring gull, also soaring with a following wind, is not the same.

In the light of what we know about the pattern of dispersal shown by the Ludwig-banded herring gull population, we might well inquire if something similar is common to all populations of this species in North America. In the literature on birdbanding, there are other studies of Great Lakes gull colonies, and these reveal no tendencies differing from those we have discussed. Herring gulls born on the Atlantic coast are somewhat less erratic in their wanderings than are Great Lakes birds, in the sense that their movements are north and south (mainly south) along the coast from the colonies, while few birds go very far inland. European herring gulls are also largely coastal and show even less tendency to travel very far. In all cases, dispersal is erratic, but usually with a tendency for some of the birds to move southward in the winter. For the most part, only young herring gulls wander any great distance.

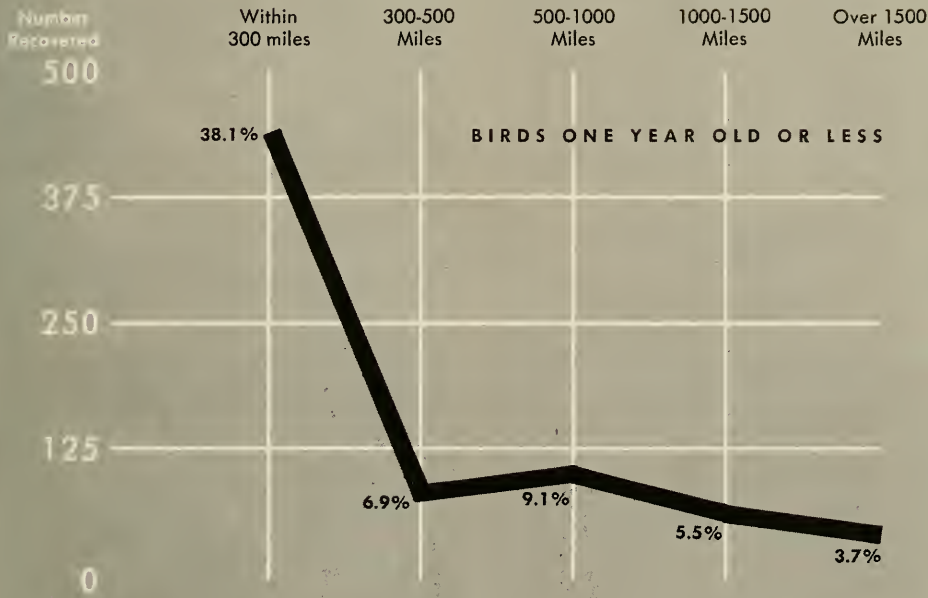
Similar patterns can also be found in many related gulls, such as the ring-billed gull and several of the Pacific coast species. Other species show interesting east-west, rather than north - south, movements. There are, however, certain gull species in which part or perhaps all of the population appears to be truly migratory. Certainly, species like the Franklin's gull, that graceful, black-headed harbinger of the prairie spring, quit their summer habitat fully and spend the winter where conditions will enable them to secure food. In this case, the entire population goes south, then returns to the breeding grounds in the spring. These movements have broad orientation and timing, but can we say the same for those of herring gulls?

In the latter, sexual maturity and the tendency for long distance dispersal seem to be almost mutually exclusive. First-year birds, in their soaring, may provide opportunity for prevailing winds and thermal lanes to take them many hundreds of miles. But, in the spring, they usually return at least to the vicinity of their birthplace. In their second autumn, far fewer birds drift away. Thereafter, as much of the year as possible is spent relatively near the colonies.

Perhaps it is just as well that some younger birds are able to escape the harsh northern winter, for mortality among their age group is extremely high. But such a pattern, in which the adult members of a species are largely resident, is not termed "migratory." It may be termed "partially migratory" if the young fulfill the generally accepted conditions of migration—that is, a regular movement from breeding areas to a fixed wintering area (in the case of most Temperate Zone migrants) and back. Such a partially migratory condition intergrades, however, with one in which the autumnal dispersal of many young birds follows a less rigid pattern and leads to less well-defined wintering areas. This latter condition in many cases is described as an "irruptive" movement. Just what term we should use to describe the young herring gulls' drifting movements is a fine point, but we should at least have reservations about extending an already broad term, "migration," to so many divergent cases.

Whatever term we choose, we may say that, in most of the herring gull populations for which we have information, the elder birds partake in little extended travel, while the immature birds show an annual pattern of dispersal in which orientation and timing are delimited only in a general sense. The movements of the young birds, as we have seen, are mainly along watercourses and coasts where the birds can take advantage of an aquatic food source, of lanes of uprising air, and of prevailing winds. We do not know to what extent they use the latter as a form of assistance, nor to what extent they avoid being aloft when the wind is blowing in the direction of an unfavorable habitat; but we hope to find out more about this, and thus to be able to understand more fully the migratory behavior of the herring gull.

DISTANCE FROM COLONIES



Birds in first year, part of the total of 1,143 gulls of all ages recovered, are graphed, above.

Although many stay within 300 miles, significant numbers of these young gulls go greater distances.

In contrast, this graph of recoveries of the older birds reveals very few moving beyond 300 miles.

A breakdown of figures shows that the older the bird, the closer to colony it is likely to remain.

SKY REPORTER

The constellation Draco and the earth's wandering pole

By Simone Daro Gossner

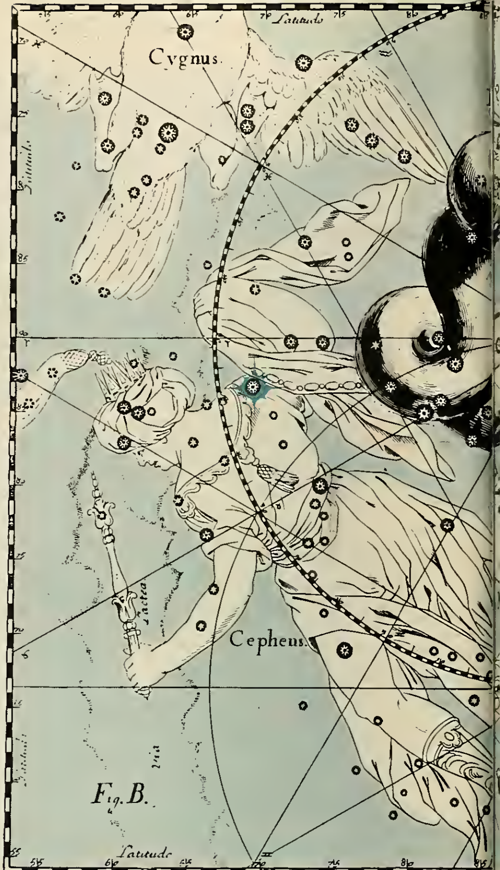
In the past year we have reviewed how astronomers and cosmologists of past centuries were able to interpret their observations and gradually to understand the structure of the universe. In contrast to this historical approach, we propose to devote this year's series to a casual survey of the heavens as they appear to the modern observer. As the occasion arises, we shall dwell at some length on unusually interesting regions and remarkable telescopic objects, but our principal purpose will be to outline the broader features of the celestial sphere and to explain the physical phenomena from which they arise.

The earth's rotation on its axis and its annual revolution around the sun are two of the principal factors that determine the appearance of the night sky. The earth's daily rotation causes the sun, moon, and stars to rise east of the local meridian and to set west of it. This does not alter the relative positions of constellations, because the entire sky appears to rotate as a solid sphere; only the direction in which a particular constellation is to be found changes continuously through the night.

To this daily, or *diurnal*, motion is superposed the effect of the earth's annual revolution around the sun. If stars could be seen in the daytime, the sun would appear against a somewhat different background every day as the earth pursues its yearly course. This effect may be re-created as follows: place a chair (the sun) in the middle of the room and, facing it at all times, walk sideways around it. You (the earth) will see the chair outlined successively against all the objects (distant stars) that line the four walls (celestial sphere). The constellations visible during the hours of darkness are similarly displaced from day to day, in a yearly cycle. (Repeat the above experiment with your back to the chair, instead. This will simulate the direction opposite the sun, or nighttime.)

The apparent course of the sun, called the *ecliptic*, traverses all twelve constellations of the zodiac. Because the moon and the planets never stray very far from the plane of the earth's orbit, they, too, are always found near the ecliptic. Thus, zodiacal constellations provide a ready frame of reference for one's orientation in the sky.

A third factor governing the general appearance of the heavens is the position of the solar system within the Milky Way Galaxy. This vast aggregate of stars, gas, and dust presumably contains a dense nucleus encircled by enormous spiral arms, the whole system being approximately disk-shaped. The sun is located off-center, near the plane of the disk. Accordingly, the Milky Way appears on the celestial sphere as a broad luminous band, forming almost a great circle. Within this band lie some of the most beautiful objects visible through large telescopes. The Milky Way may thus be considered as another fundamental frame of reference in the sky.



Circle surrounding Draco, *above*, reproduced here from the plate in Hevelius' *Prodromus* (1690), traces the path that

The appearance of the sky has changed appreciably within historic times, because of the peculiar behavior of the earth's polar axis. At present, the north end of this axis points almost exactly toward the last star in the tail of Ursa Minor (known popularly as the Little Dipper). That star is called Polaris—or the pole star—for this reason. However, the direction of the earth's axis does not remain fixed; it describes a complete circle on the celestial sphere in approximately 26,000 years. Centered roughly on the constellation Draco (see illustration), this motion carries the north celestial pole near Alpha Draconis (where it was about 4,000 years ago), through its present position in Ursa Minor, then on to near Alpha Cephei (*ca.* A.D. 7500), and on to near Vega (which will be the pole star in A.D. 14,000).

The direction of the polar axis, in turn, determines the location of the celestial equator, which may be imagined as the extension of the earth's Equator onto the celestial sphere. At the spring equinox, the sun—following the

he earth's polar axis pursues every 26,000 years. The ole star, 4,000 years ago, was Alpha Draconis, at right.

cliptic—crosses the Equator from south to north. According to a tradition of twenty centuries' duration, this quinoctial point is still called the First of Aries. But the ircular motion of the pole is reflected in a similar otation of the celestial equator, with the result that the 'irst of Aries regresses continuously through the zodiac in a direction opposite to the apparent motion of the un) and goes full circle in 26,000 years. By now, the 'irst of Aries, belying its name, is well out of that contellation and lies somewhere in Pisces, almost 30° away.

Although the time of year is important in determining vhat part of the sky may be visible, the observer's latiude plays an even more restrictive role. Because of the :arth's diurnal rotation, each star describes a circle iround the pole (i.e., a small circle, parallel to the Equator). An observer in the northernmost reaches of he Arctic would see the north celestial pole nearly overiead: the celestial equator would lie essentially in his iorizon, and all stars south of the equator would remain erpetually out of sight. Near the South Pole, the situaion would be reversed, and only southern stars visible.

In theory, an observer located at the Equator and patient enough to watch every night, would eventually see every inch of the celestial sphere, since the North Pole would lie on his northern horizon, the South Pole on his southern horizon, and the Equator would reach from east to west across his zenith. In fact, he would not do quite as well, because of the haze and occasional landscapes, which hamper observations near the horizon.

These extreme cases are seldom encountered, anyway, and most people look at the sky from some intermediate latitude. A convenient rule of thumb to remember is that the elevation of the pole above the horizon is always equal to the observer's latitude. Thus, in Philadelphia, for example (latitude 40°N.), the North Pole has an altitude of 40°, and stars within 40° of the pole never set. But this means also that the Philadelphian, facing south, sees the celestial equator cross his meridian at an elevation of 50° (50+40=90). Thus, every clear night he may see, above his southern horizon, a few stars which, optimistically, may be as much as 40° or 45° south of the equator. With persistence, an observer at that latitude may eventually see 70 to 75 per cent of the entire celestial sphere: but he will never see the southernmost stars. Regrettably, some of the most beautiful objects in the sky are found in the Southern Hemisphere—the Magellanic Clouds, the Southern Cross, and some of the richest regions of the Milky Way.

As the zodiac and the Milky Way provide large scale means of orientation, the constellations serve a similar purpose for smaller areas. For the most part, constellations are fortuitous groupings of stars, which happen to lie in the same general direction from the earth. But their distances may differ greatly and, as each star has an individual space motion, the shape of a constellation may change progressively over the centuries. They are sufficiently permanent, however, so that we still recognize the forty-eight constellations of the ancient Greeks. To these, a few have been added in modern times, particularly in that part of the southern sky that was not visible from the Mediterranean area. Although we treasure the mythological figures that adorn them in old star atlases, we have almost forgotten that, for a long time, these figures were the only means of designating a star's position. To the end of the sixteenth century, stars in Draco, for example, would be described as being "over the right eye," "at the extremity of the head in front of the right ear," "following the third twist of the serpentine body," and so forth. This practice explains the great similarity of design found in illustrations of constellations, from the medieval codices, through the block books of the Renaissance, to the copper engravings of the seventeenth and eighteenth centuries. Each artist expressed the taste of his times: the hat of Cepheus, the robes of Virgo, the armor of Perseus were altered at will. But the right eye of Draco was always beneath the same star and its serpentine body always showed the traditional number of twists.

Modern astronomers had to forego these picturesque designations and substitute a more utilitarian system of co-ordinates when the introduction of the telescope, and later of photography, so increased the number of known stars that the need for a precise mode of identification became imperative. The old names of constellations are still used, and we shall refer to them throughout this series, but their boundaries have been redrawn for the sake of uniformity. Stars within them may have a Greek-letter name if they are bright, or only a serial number.

THE SKY IN JANUARY

From the Almanac:

New Moon	January 6, 7:36 A.M., EST
First Quarter	January 13, 12:02 A.M., EST
Full Moon	January 20, 1:17 P.M., EST
Last Quarter	January 28, 6:37 P.M., EST

The earth will be at perihelion on January 2. On that date it comes closest to the sun on its yearly journey and, in accordance with Kepler's laws of planetary motions, it travels at its greatest orbital speed.

For the visual observer:

The planets make a poor show this month, being in general too close to the sun to be observed.

Mercury, in the evening sky, will be at its greatest eastern elongation on January 20. It should be visible low over the southwestern horizon near that date. At elongation, the planet's magnitude will be −0.6 and it will set an hour and a half after the sun, whereas it will set only forty minutes after the sun on January 1, and one hour after the sun on January 31.

Venus, in the morning sky until January 27, will rise twenty minutes before sunrise on January 1 and will remain too close to the sun to be observed during the entire month. The planet will be in superior conjunction on January 27 and will enter the evening sky on that date.

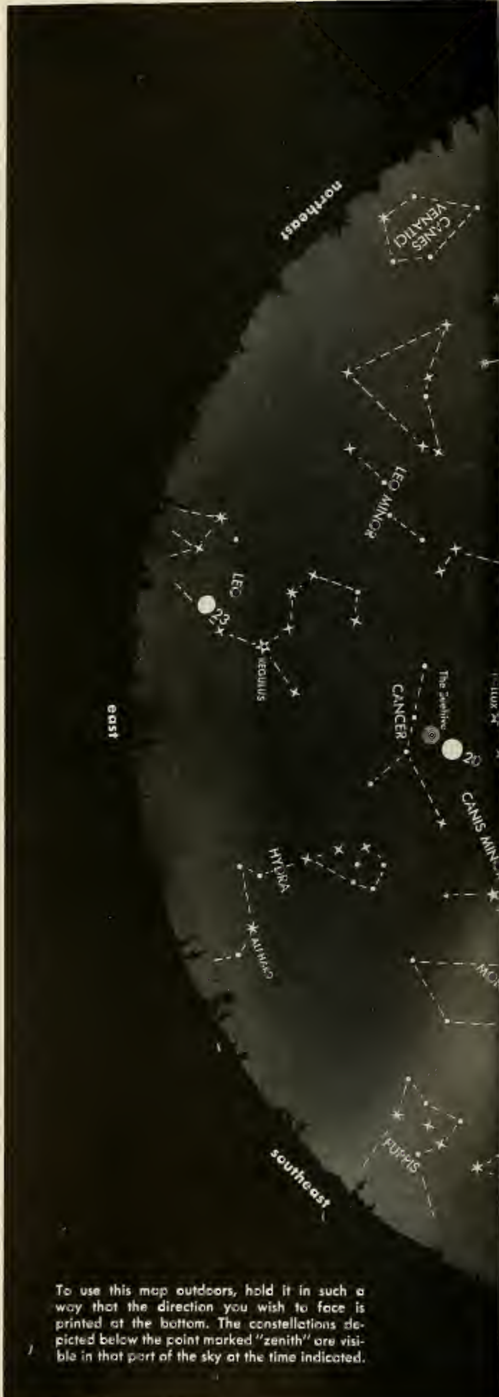
Mars, in Sagittarius, has barely passed conjunction. It will be faint (+1.5 magnitude) and inconveniently close to the sun throughout the month. Mars will be in the morning sky but, even at the end of January, it will rise a scant thirty minutes before the sun.

Jupiter, in Capricornus (−1.5 magnitude), will be observable in the early evening hours during the first half of the month. Low in the southwestern sky at dusk, it will set two hours and a half after the sun on January 1, and one hour and a half after the sun on January 15. By the end of the month it will set only thirty minutes after sunset and will be too close to the sun for observation.

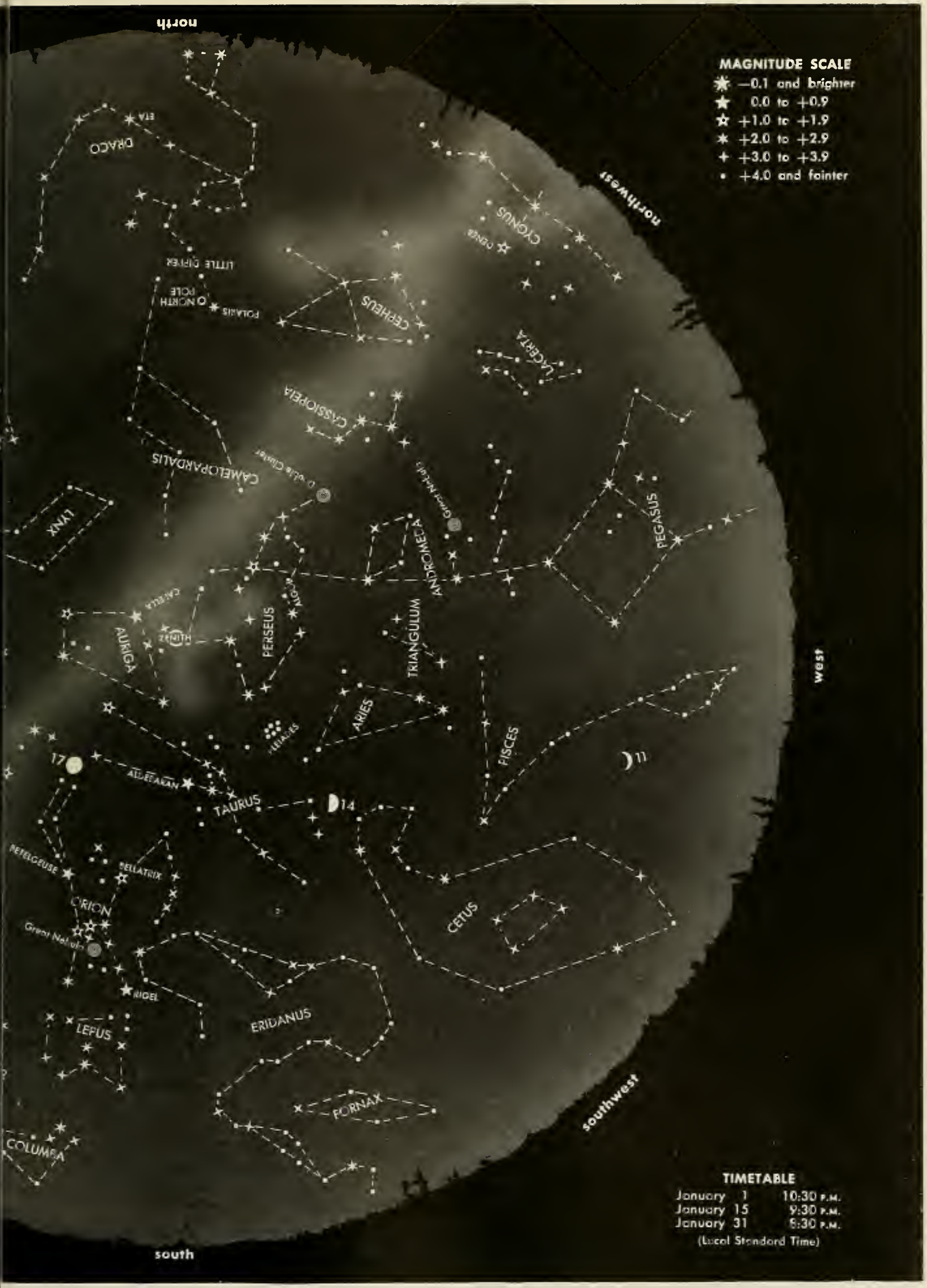
Saturn, also in Capricornus (+0.8 magnitude), will be in conjunction with the sun on January 22 and will be lost in its glare for several days on either side of that date. Thus, it will be observable only during the first few days of the month. On January 1, Saturn will set approximately one hour and a half after sunset.

In the absence of suitable planets, the amateur observer may wish to familiarize himself — or renew acquaintance — with some of the bright stars in the January evening sky. Facing south near the time indicated on the map, and starting with Capella (nearly overhead), one can identify successively Aldebaran (in Taurus), Betelgeuse and Rigel (in Orion), and Sirius (in Canis Major), which will lead the viewer in a loose zigzag to the southeastern horizon. Worthy of note is deep-red Betelgeuse, whose radius is believed to exceed one and a half times the radius of the earth's entire orbit. Betelgeuse's brightness varies irregularly from +0.5 to +1.1 magnitude. It is suspected that this variation in magnitude may be caused by a slow pulsation of the star.

On the preceding pages, MRS. GOSSNER offers the first in her 1962 series — a survey of the celestial sphere.



To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.


MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
north
northwest
west
southwest
south
DRACO
ETA
LITTLE DIPPER
NORTH POLE
POLARIS
CYGNUS
DENEB
CEPHEUS
LACERTA
CASSIOPEIA
CAMELOPARDALIS
Double Cluster
Great Nebula
LYNX
ANDROMEDA
PEGASUS
CAPELLA
AURIGA
ZENITH
PERSEUS
ALGOL
TRIANGULUM
ARIES
PLEIADES
PISCES
17
11
ALDEBARAN
TAURUS
14
BETELGEUSE
BELLATRIX
ORION
Great Nebula
RIGEL
CETUS
ERIDANUS
LEPUS
FORNAX
COLUMBA
TIMETABLE
January 1 10:30 P.M.
January 15 9:30 P.M.
January 31 8:30 P.M.
(Local Standard Time)

A Key to Ferocity in

Bears

Seldom-observed behavioral traits may vindicate a reputedly dangerous animal

By Peter Krott

It is generally known today that bears — whether American black bear, brown bear, grizzly bear, or polar bear—are not suitable as pets. and that they make dangerous and disagreeable wards even in zoos and circuses. To what extent this also holds true for the moon bear—the Asiatic cousin of the American black bear—for the Malay bear, for the sloth bear, and for the spectacled bear, is not in discussion here. It is known, furthermore, even though the subject is unpopular, that in the American national parks a number of visitors are more or less seriously injured by bears each year. Thus, whether in captivity or in the freedom of national parks, these droll and amiable-looking animals prove to be more dangerous to human beings than are, to take extreme examples, lions, tigers, and wolves. At the same time, one seldom hears of a bear of any species, living undisturbed and unmolested in the wild, attacking a human being, while such is not the case for lions, tigers, and wolves.

Beyond this, it is perhaps significant that our ancestors did not domesticate the bear, although they could well have had reason, as well as opportunity, to do so. The bears would have constituted strong beasts of burden, not to mention a first-class source of meat and fat, and they could have been fed more easily in the northern barren lands than could horses, cattle, or pigs. We know that many forms of bear cults are spread over wide areas of the primitive world. Many animals used in cults may well have constituted the earliest forms of today's domestic animals. With the bear, this was certainly not the case.

In the course of recent research, let it be said at the start, I had no intention of venturing to solve the "secret" of why bears are dangerous. Rather, in June, 1958, I had merely undertaken the interesting and gratifying task of

Bear cubs, seen here tumbling in an alpine meadow, devote very little time to such play. Unlike many other young animals, bears stay busy hunting food.

After being fed by bottle until about five months old, bear cubs were given complete freedom and, with it, the need to conduct their own searches for food.

studying the way of life of the last of the brown bears *(Ursus arctos)*, which exist in Central Europe (in an area in the Italian Alps). Day after day, I lived with and observed bears in complete freedom. It was as a by-product of these observations that one day I realized why bears in contact with human beings can, and under certain conditions must, become dangerous.

In February, 1959, I obtained two four-week-old bear cubs from Czechoslovakia — a male I called "Bumsli," and a female known as "Sepha." At first, I bottle-fed them in my home in the village of Carisolo, which lies in the midst of the Italian bear district. I then moved up into the mountains with them and set up my headquarters in an abandoned mountain hut. There Bumsli and Sepha were allowed to move about freely and could live and go as they pleased. An old goat stable next to my hut served as a den to which they retired voluntarily when they wished to sleep. I did not make any attempts to "tame" my bear cubs, to train them, or to keep them as pets. Bumsli and Sepha knew neither chains nor cage, and were not permitted to enter my hut. Nor, once weaned, were they fed by me: instead, they were forced to forage for their own food, for my purpose was to learn, with their help, the various articles on which the Eurasian brown bear feeds.

Since my wife and our two children also lived with me and the bears, at least from time to time, several persons advised me to give up the venture. They gave three reasons for the dangers involved for human beings in close contact with bears. First, it was said, man cannot tell from a bear's facial expressions when it is in bad temper and, therefore, cannot retreat in time. Second, the bodily strength of a bear is so great that even an unintentional blow with its paws—as, for instance, in play—can kill the keeper. Finally, these advisers warned, bears' "nervousness" and the ease with which they can take fright is such that, at any moment, the animal can turn aggressive and seriously endanger a human being who stands nearby.

The first point—facial expression—I soon discovered to be incorrect. Even my two sons, six and four years old at the time, were able to read the facial expressions of Bumsli and Sepha dependably and tell exactly what was up. In fact, from a bear's eyes and its very mobile nose one can readily interpret precisely what mood the animal is in. This first danger, therefore, we could put to one side.

The third danger of which we were advised did not play any important part in our lives, either, because nothing prevented Bumsli and Sepha from turning to flight when frightened. They took ample advantage of this opportunity, so that their fear never had cause to turn into aggression toward any member of our family.

But the second point, the danger from an unintentional, playful stroke with the paw, seemed to me to be of importance. However, I soon realized that bear cubs, when growing up in the absolute freedom granted to Bum-

Unlike true carnivores, who depend solely on meat and carrion, bears can

and Sepha, play very little—much than do other young beasts of prey ive observed. This seems to be be- se they have no spare time: they mostly occupied with the search food, and at other times they are ing. I discovered, furthermore, t they seldom play even with their ther (or the living being whom they ognize as their "mother"—in this e, my wife and I). They play more quently with each other, and they d to play with our children, too.

At such times, there was nothing to but intervene and separate children l bears, much to the disappointment all parties. Although, as the boys' ıer, I had to be cautious, I am still convinced that the bears would e hurt the children, even uninten- ıally. The bears' invitation to play— well as their playing itself—was, in t, extremely timid, and even tender. ey were far less wild than, for in- nce, the young wolverines with ich we had lived in Sweden a few irs before (NATURAL HISTORY, Feb- ıry, 1960). On the contrary, when ys and bears played together, the mer were very frequently the ones o were more brutal.

Thus, I came to realize that the sons given by zoological colleagues to why bears are dangerous could ther be the only reasons, nor the st important ones, for our life to- her with Bumsli and Sepha went ng splendidly. We were not the first

UNCONFINED, BROWSING BEARS, in midst of trees to climb and with water nearby, were perfectly tractable, and even apparently enjoyed human company.

gularly supplement such a diet with ass, berries, insects, and even worms.

to experience such a relationship. I knew of three authentic cases in which men lived peacefully, and without accident, together with bears, even after the animals were fully grown.

THE Swede Hj. Edström, on his way back from the Russian polar coast, became lost in the taiga, but was fortunate enough to meet a fur hunter who took him in, gave him shelter and food, and then led him out of the wilderness. Edström reported that the hunter lived in a cave with a huge bear that he had named "Serge." For years, the animal wandered in and out of the cave with the greatest freedom. It even accompanied the hunter now and then on his forays, but otherwise searched for its own food in the taiga.

Again, the Swedish forester G. Schröder, in the year 1865, came upon a bear's den, killed the mother, and took two cubs. He bottle-fed the female in his home and let her run free around his secluded property for nearly three years. No accidents occurred.

Finally, the famous James "Grizzly" Adams, who lived in the mountains of California during the first half of the nineteenth century, had, altogether, four adult grizzly bears that followed his every step in complete freedom. One even carried his hunting equipment and served him occasionally as a riding animal. Adams, too, never was hurt by his four bears while he shared the wilderness with them.

Surely, I thought, what had been carried through successfully three times in the past I, too, should be able to accomplish. And I did succeed, for —exactly as my predecessors in similar circumstances—I apparently managed to do the right things in my dealings with these "dangerous" animals.

STARTING in April, 1959, when we were still living in the village with our three-month-old cubs, we would sometimes offer them cookies, pieces of cake, apples, and other choice bits of food. In doing this, we observed that our bears enjoyed the delicacies, but would never take them out of our hands. They ate the food only when we put it on the ground.

We did not pay much attention to this curious behavior, especially since we had, of course, no intention of training or even feeding the animals when weaned. Besides, at that time, we took walks with them through the woods along the river that runs near our village, and there they had the opportunity to supplement their diet with leaves, grass, and ants.

After our move up to the mountains, we had no more chances to observe how Bumsli and Sepha reacted to proffered food, since we could no longer afford extras for them (we had enough

DR. KROTT has spent the last three years in the Italian Alps studying bears, using the same methods that he applied in Finland and Sweden before writing his noted book on wolverines.

to do to lug our own). Once, on a walk that we took early in July, 1959, Bumsli suddenly started sniffing at a pocket in which my wife kept small test tubes of alcohol and ether for collecting insects. He tore out these tubes, pulled off the corks, and then devoured both corks and contents. During all this, he growled ferociously, and would no doubt have bitten my wife had she attempted to take her equipment away from him by force.

AFTER this warning, we took care to carry nothing edible—or anything that the bears might deem edible—in our pockets when we went out strolling with them. From this point on, we also had to stop carrying our own food in a knapsack, and were forced to discontinue pleasant little picnics in the grass. With rumbling stomachs, we would accompany Bumsli and Sepha, and only too often my mouth watered when I watched the bears eating the provender nature so abundantly afforded them.

When, toward the end of July, the first raspberries and blackberries ripened, our fasting time came to an end. We and our children unhesitatingly plucked the juiciest fruits, with no heed to any possible attacks by the bears. And, lo and behold, there were no attacks! We could pluck berries from the same bush, the same twig, even the same cluster, alongside Bumsli and Sepha. Had we wished, of course, even earlier we could have browsed or dug for worms alongside them: later, when Bumsli and Sepha ate sheep and goats, they allowed us to cut off a piece of the prey ourselves, or to stand near as they fed.

WHEN BERRIES WERE RIPE, author's family could accompany bears on foraging trips and even pick from the same bushes.

Filled cans, however, were considered fair prey by animals, and had to be hidden while the bears' attention was diverted.

We found, in fact, that we could do erything they did. However, we were ›t permitted to eat anything, or hold ıything in our hands that they de- red and were unable to obtain, or ›tained too slowly.

THE revelation came to us: anything edible that is *in motion* sig- fies, under any circumstances, prey r the bear. Furthermore, this animal ›viously lacks both the ability to be d and the associated ability to learn recognize and accept, in any posi- ve sense, a feeder.

At this point, we must note that all embers of the bear family (Ursidae) e, in many respects, very peculiar iimals. Phylogenetically, they belong our more recent mammals; in the ırliest Pleistocene they were not rep- :sented in the form of any of the now cisting species. Physiologically, they e true carnivores—at least this is true the American black bear, brown

Bumsli and Sepha often demonstrated restrained affection for their adoptive "mothers" and were friendly except if tempted by concealed or visible food.

bear, polar bear, and grizzly bear—but they cannot hunt enough warm-blooded prey or find enough carrion in every region they inhabit. They are, therefore, also forced to feed on insects and vegetable matter. At a certain season (before their winter "sleep"), they particularly need starch and sugar: this they find mainly in fruits and berries (the polar bear, too, likes to browse on whortleberries and cranberries whenever they are available). In the functioning of their nourishment cycle, therefore, bears behave partly like carnivores and partly like herbivores. And that is the crucial point of interest to us here.

AMONG most true mammal predators, the mother (sometimes also the father, or both parents together) carries the first gobbets of flesh to the young, chews them for the babies, and at times even feeds them directly. With the bear, it is different. The female brings forth her young in her winter den, which she leaves only later, together with the cubs. Bear cubs are constantly near their mother. Thus, the female bear has no occasion to hunt for prey and carry it to her young (the males do not take care of their offspring in any way). At winter's end, the mother bear leads her young to food, but she never feeds them. That, I think, is why Bumsli and Sepha, at first, did not want to accept any food from us when we held it in our hands. In true bear fashion, they accepted from us, as their "mothers," only milk from the bottle. When we offered them milk in a bowl, they stubbornly refused to drink it.

Still, this does not explain why later they did not want to be fed, and why they could never learn to leave us in peace when we carried edibles in our pockets. Even elephants, which, like bears, do not carry food to their young but lead them to it, can easily become accustomed to being fed. But with the bear there clearly exists some great, even crucial, behavioral obstacle.

By approximately their seventh

A THWARTED RAID on pantry reveals length of bear's claws, potent arguments against human attempts at hand-feeding.

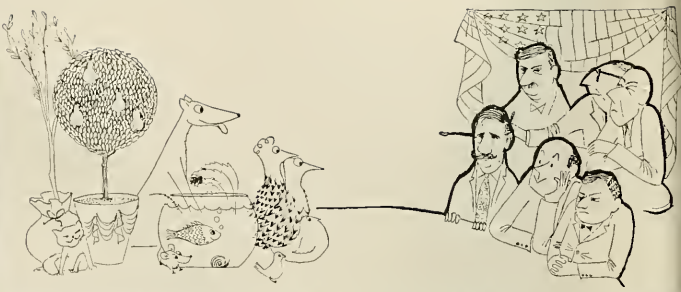
TYPICAL BEHAVIOR of bears included touching face of the author with snouts, *right*, but they were shy with strangers.

month. the bears' predatory behavior —at least in the Eurasian brown bear, as I had opportunity to observe—has been fully developed. The ethologists would say that the appropriate neuromotor pattern has matured. From that time on. the bear reacts to food objects in motion, whether these be a mouse dashing by, a piece of sugar that is carried in a pocket, or an apple held out to it in a hand, as it would to prey that has to be seized—it slashes at it with its paw.

To summarize: a herbivore can be fed because its body is not in any way adapted to the movements necessary for seizing prey. Many carnivores. in turn. acquire the ability to be fed as a result of parental attention. The bear lacks this ability and evidently cannot acquire it. That, I believe, is the deciding factor in the danger of bears living in contact with men. The way to the bear's heart is not through its stomach; that is what is hard for humans to understand, since we ourselves are capable of being fed, as are others among the true predators.

THIS, then, is the reason for the numerous accidents caused by bears in the national parks, where they are fed with great enthusiasm (and through greater ignorance) by the visitors. It is also the reason why zoo and circus bears never become completely "hand-tamed." Furthermore. it explains why it is scarcely convenient to keep any American black, brown, polar, or grizzly bear as a pet.

On the other hand, the Russian fur hunter, the forester Schröder, and "Grizzly" Adams. in their isolated habitations, presumably had just as little food available for their bears as we did in our Italian Alps. Their wards were thus forced, as were Bumsli and Sepha, to forage for themselves. These men. like us, were never hurt by their bears. Here, it seems to me, lies the main reason why the bear has never developed into a domestic animal: a wild creature that does not permit itself to be fed will, in all probability, react aggressively to any feeding attempt. Such an animal cannot readily be domesticated!



WASHINGTON NEWSLETTER

By Paul Mason Tilden

The Congressional "Vacation"

During the latter part of September, the House of Representatives gathered its members together, passed a supplementary general appropriations bill, sent it to the Senate on a "take-it-or-leave-it" basis, and cheerfully departed a city that had offered a steady summer diet of 90° plus weather. The bill contained a number of items highly distasteful to many Senators; yet, faced with the alternative of no appropriations bill or a special session of Congress, the Senators passed the bill with many a cry of injured dignity, and then went off to their homes, too.

It was the end of the first session of the Eighty-seventh Congress, and Congressmen from both houses dispersed about the country and into foreign lands on what is commonly supposed by the public to be a "vacation"—those few months between the first and second sessions of a Congress. Actually, for many Congressmen, the hiatus is hardly a vacation in the accepted sense. It is rather a time to devote to more work, political and otherwise.

Not only does the recess give a Congressman a chance to hold a moistened finger to local political breezes; it also provides the conscientious officeholder with an opportunity to further his knowledge and improve his judgment on matters that concern his committee or subcommittee assignments, which may be many. And, truly, it is in the committees and the subcommittees that the real work of Congress is accomplished.

Many Senators and Representatives use part of their interim vacation to investigate the bills referred to their committees or subcommittees. To make an intelligent estimate of a bill, a committeeman must at the very least be conversant with many of its details. During his spare time he may hold hearings, visit sites, estimate costs, talk with experts and specialists, sound out local sentiment, and in general formulate an accurate picture of the matter under consideration. Accuracy is essential in his committee reports; he is well aware, or is soon made aware, that the bills he will consider or amend in committee will almost certainly come under the merciless scrutiny of an opposition eager to expose every flaw and every misplaced comma. A bill *must* say what it means.

Thus, for many Congressmen, the end of a first session is not the signal for playtime; it merely sounds the bell for more working days.

Defeat at the Bridge

The 1961 defeat of conservationists at Bridge Canyon, in the "slickrock" wilderness country of southern Utah, might well be likened to the disaster suffered by General George A. Custer and his detachment of Seventh Cavalry troopers on the Little Bighorn River, some hundreds of miles to the north, in the summer of 1876. In both cases the struggle was bitter and courageous, and conducted against great odds; in both cases, also, the outcome was absolutely permanent in nature.

As predicted in this column (Natural History, June-July, 1961), the fight for some sort of protection for tiny Rainbow Bridge National Monument was permanently lost in the first session of the Eighty-seventh Congress. On a close vote, the House Appropriations Committee rejected a subcommittee recommendation for funds to protect the monument from the rising waters of Lake Powell, behind the Glen Canyon Dam of the Upper Colorado River Storage Project. A last-ditch amendment to restore the appropriation—made on the floor of the House—was ruled out of order by the parliamentarian as an attempt to legislate in a money bill. The fight was lost.

"The Committee," said the House report, "continues to see no purpose in undertaking an additional expenditure in the vicinity of $20.000,000 in order to build the complicated structures [a barrier dam in Bridge Canyon] necessary to provide the protection proposed."

ɪnservationists felt that figure was high | at least three times the sum needed, d that the comment came rather lamely om a Congress that had just authorized record $96 billions for other purposes.

The same arguments that have been ard for several years defeated the pro- ction money. Lake waters would do damage to the famous bridge, either ıysically or scenically; protection is ıt economically feasible; what harm ould the backed-up water do, anyway? It was urged that the real question ıs one of principle. Should, or should ıt, man-impounded waters be allowed intrude into units of the National ırk System? Despite a previous com- itment to the contrary, Congress ap- ırently felt that they should . . . and at was unalterably that.

In the National Parks

THE first major addition to the na- tional park system since the estab- shment of the Virgin Islands National ark in 1956 was accomplished during ıe first session of the Eighty-seventh ongress, when 26,670 acres of outer ape Cod, Massachusetts, became the ountry's first National Seashore. (Cape atteras, which is the only other com- arable area in the park system, is a ational Seashore Recreational Area.)

The bill, signed by President Kennedy ı August 7 to create the Cape Cod pres- rvation, was authored by Senators altonstall and Smith of Massachusetts, ith a number of amendments—making ıe bill acceptable to the House—agreed pon by a House-Senate conference ommittee. Of chief importance among ıe amendments was one preventing the ecretary of the Interior, under whose ırisdiction the new area falls, from ıcurring obligations for land purchase ı advance of Congressional appropria- ons. This provision inspired a number f Cape developers and citizens—owners f land to be included in the Seashore—) apply to town authorities for building r alteration permits, apparently under ıe impression that property improve- ıents would place them in an advan- ıgeous position when it came time for settlement with the National Park ervice. A few permits were issued.

Late in the session, however, a supple- ıental appropriations bill authorized ome money for land acquisition. Conser- ationists did not miss the implications f the authorization-without-appropria- ion variety of legislation, as it applied ɔ several other national seashores that will doubtless be considered by Congress during the next session. Notable among these are Point Reyes in California and Padre Island in Texas.

Ever since the opening of the Eighty-seventh Congress in January, 1961, the National Park Service has brought forth several reports and proposals for major additions to the park system. Ordinarily, a printed report and proposal is interpreted as an indication that the Service has completed its formal study of a proposed preservation; that its biologists, ecologists, botanists, geologists, park planners, and others have completed their studies and made their reports; that the reports have been evaluated by Service headquarters in Washington; and that the Service is ready to see legislation introduced into Congress to acquire an area for preservation.

Thus, proposals have been made in the past few months for the establishment of an Allagash National Recreation Area of nearly 300,000 acres, located in the wild and largely unspoiled Allagash River wilderness country of northwestern Maine; for a Prairie National Park of about 57,000 acres in Pottawatomie County, Kansas, for the preservation of a representative sample of the scenery, plants, and animals of the original American prairie; and, most recently, a proposal for the establishment of the Sleeping Bear National Seashore—77,000 acres of superb beach, dune, forest, and lake on the northwest coast of Michigan's Lower Peninsula, in Leelanau and Benzie Counties.

The outlook for eventual incorporation of these areas into the national park system, as seen by the writer:

Allagash Recreation Area. Barring a profound change in attitude on the part of the people of Maine and their representatives, the prospect is dim, indeed. Paper and lumber company opposition is strong, and paper and lumber play a vital part in the economy of this state. As yet, no legislation has been introduced into Congress on the subject.

Prairie National Park. Opposition almost entirely local, and not severe. Legislation to establish such a park has been introduced; outlook judged good.

Sleeping Bear National Seashore. Opposition mostly local, but strong. Outlook, perhaps fair. Legislation to create area has been introduced.

The Mount Vernon Dispute

A controversy that has been simmering for several years on the doorstep of the nation's capital was suddenly settled in the first session's closing hours.

For some time, the Washington Suburban Sanitary Commission had contemplated erection of a huge sewage disposal plant on the Maryland shore across the Potomac River from stately Mount Vernon, historic shrine near

Alexandria, Virginia, and a bare ten miles south of Washington. Mount Vernon, prime yearly target for hundreds of thousands of visiting American men, women, and children, is the estate of George and Martha Washington, kept intact and immaculate by the Mount Vernon Ladies Association. Despite outraged cries of various people and organizations including Senators, Representatives, Governor Almond of Virginia, park people, conservationists, and homeowners along the Maryland shore—Maryland officials seemed little inclined to attach much importance to the brutal case of aesthetic assault and battery, and even less inclined to seek a more fitting site for the treatment of sewage. They went so far as to decline a Congressional request for postponement of construction activities pending a further study of the matter. They went too far, as it turned out. A House Joint Resolution, sponsored by staunch conservationist John Saylor of Pennsylvania, whipped through both House and Senate, and was sent immediately to President Kennedy. The resolution made available to the Interior Department the entire Maryland shore line across from Mount Vernon for preservation "in a manner that will insure, insofar as practicable, the natural beauty of such lands as it existed at the time of construction and active use of Mount Vernon Mansion. . . ."

Air Pollution Testing Stations

JUST as many of the nation's waterways have been thoroughly polluted with industrial wastes, sewage, and the silt of mistreated agricultural lands, so the atmospheres of our larger urban centers have been polluted by the waste gases of the creeping automobile, bus, and truck hordes that daily descend on the city dweller and his "downtown" district. Added to the miseries and potential dangers of the now-commonplace "gasoline fog" of the American metropolis are the fumes and vapors of industrial stacks, oil furnaces, trash disposal units of apartment colonies, and all the other fume-producers that are part and parcel of a twentieth-century city.

Some of the gaseous pollutants of city air have been suspected of causing, or at least contributing to, lung cancer and other human maladies; long suspected in this connection is the carbon monoxide of internal combustion engine exhausts. The U.S. Public Health Service, a bureau of the Department of Health, Education, and Welfare, has recently launched a construction program that will provide eight major American cities—Philadelphia, Detroit, Los Angeles, San Francisco, Cincinnati, New Orleans, Washington, and Chicago—with stations that will perform around-the-clock monitor service for their atmospheres. The eight stations, to be known as "Air Pollution Test Centers," will continuously sample the air for seven different gaseous pollutants, and transmit the data obtained to the Robert A. Taft Sanitary Engineering Center in Cincinnati for analysis. Gaseous compounds to be checked are carbon monoxide, sulphur dioxide, nitric oxide, nitrogen dioxide, ozone (an unstable allotrope of oxygen), total hydrocarbons, and total oxidants.

The Service emphasizes that the new monitoring stations are not to be substitutes for the National Air Sampling Network, which has been operating nationwide since 1957, but rather as a supplement to the latter, which conducts atmospheric testing only periodically.

Key Deer Appear Safe

IN 1951 the Key deer, inhabitants of the Florida Keys and smallest representatives of all American deer species, were threatened with extinction. At that time the mammals, which when fully grown are about the size of a collie dog, were estimated to total no more than 32 individuals. In 1954, Congress established the National Key Deer Refuge—282 acres of leased land in the Keys—and placed it under the jurisdiction of the Bureau of Sport Fisheries and Wildlife, in the U.S. Fish and Wildlife Service. Since that time, thanks to land acquisition by the Bureau and donations of both land and money by interested individuals and organizations—conspicuous among the latter is the North American Wildlife Foundation—the Key deer possess a refuge of 6,932 acres, and their numbers are estimated at more than 200. Barring natural or man-caused calamity, the diminutive mammals now seem destined to continue as a viable species.

Education Is the Answer

REPEATEDLY during the recent past, the plight of many of Africa's great mammals has been called to the attention of the American public. There is an almost complete lack of coherent conservation programs or policies at government levels among the seething African states, outside of the already established national parks, which are themselves in difficulties. This lack has compounded a natural disaster in the form of drought, making dubious the future of a number of long-familiar African big game mammals.

Political unrest and upheaval has made wildlife protection difficult even in

such great African preserves as Albert, Garamba, and Upemba, where poaching and boundary encroachment pose serious problems of management for staffs that have been cut to half their former numbers, or less; and where money to meet vital payrolls is totally inadequate and occasionally non-existent.

One group of American conservationists believes that the only permanent answer to the dangers confronting large African mammal species lies in a program of conservation education for interested Africans; something that recipients can take back to Africa and spread as rapidly as possible. Under the leadership of United States Tax Court Judge Russel E. Train, of Washington, D. C., this group, recently organized under the title of The African Wildlife Leadership Foundation, sponsors scholarships for conservation-conscious Africans. It has already given its first grant to a young native of Kenya, East Africa, who will study biology and wildlife conservation at Central Missouri State College. Among the trustees of the new conservation education organization are Maurice H. Stans, one-time Director of the Budget; Kermit Roosevelt, grandson of the late President Theodore Roosevelt, Harold J. Coolidge, executive director of the Pacific Science Board of the National Academy of Science, and Edward C. Sweeney, former general counsel for the U. S. General Services Administration.

Neither Judge Train nor the other trustees of the organization are under any illusions regarding the difficulties facing their program. The staff seems fully aware that, for some of the large African mammals, the hour is already late, and that some may have vanished by the time the program reaches fruition. Odds on success of the program, Judge Train said, are "terribly long."

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New York 24, New York

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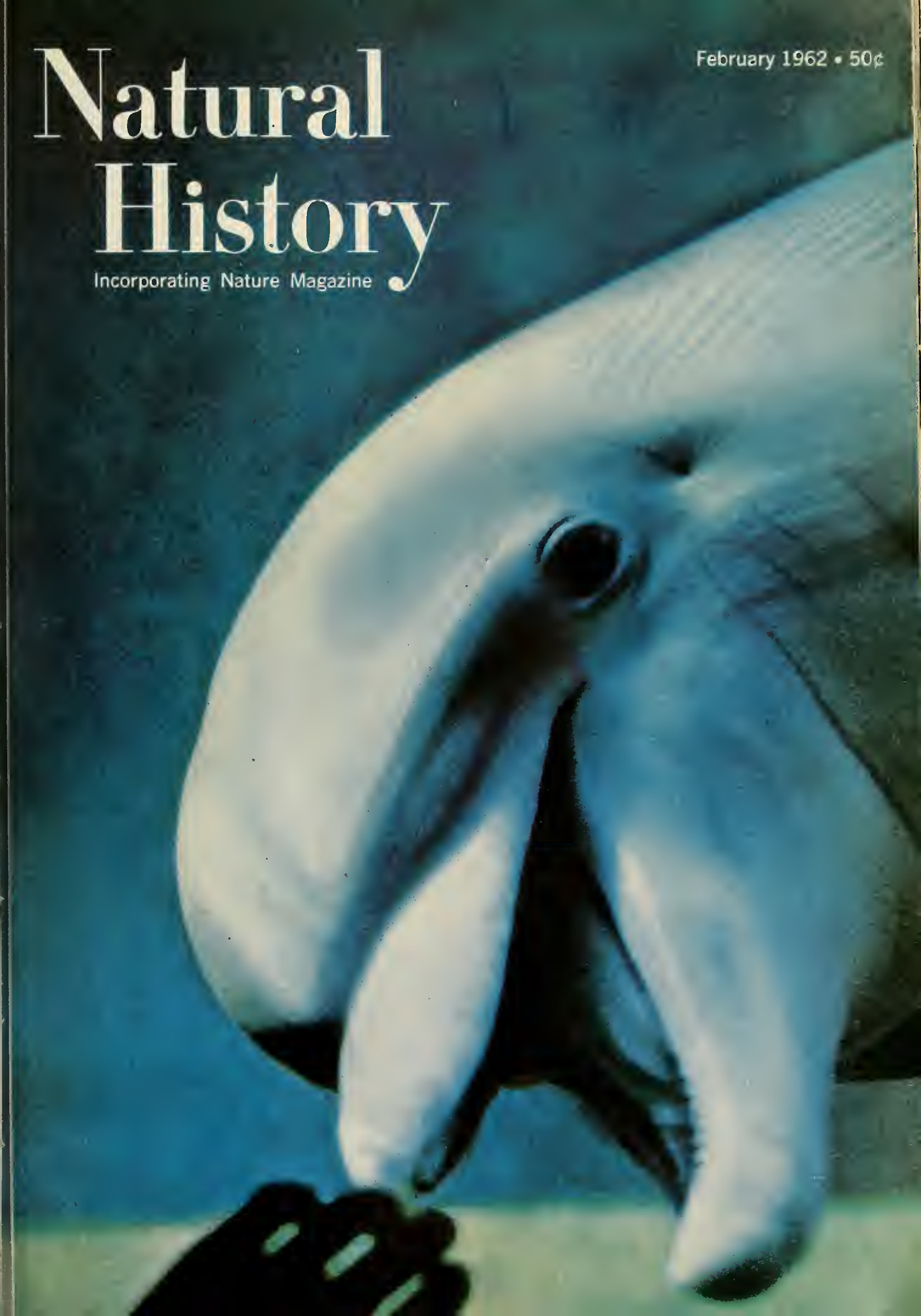

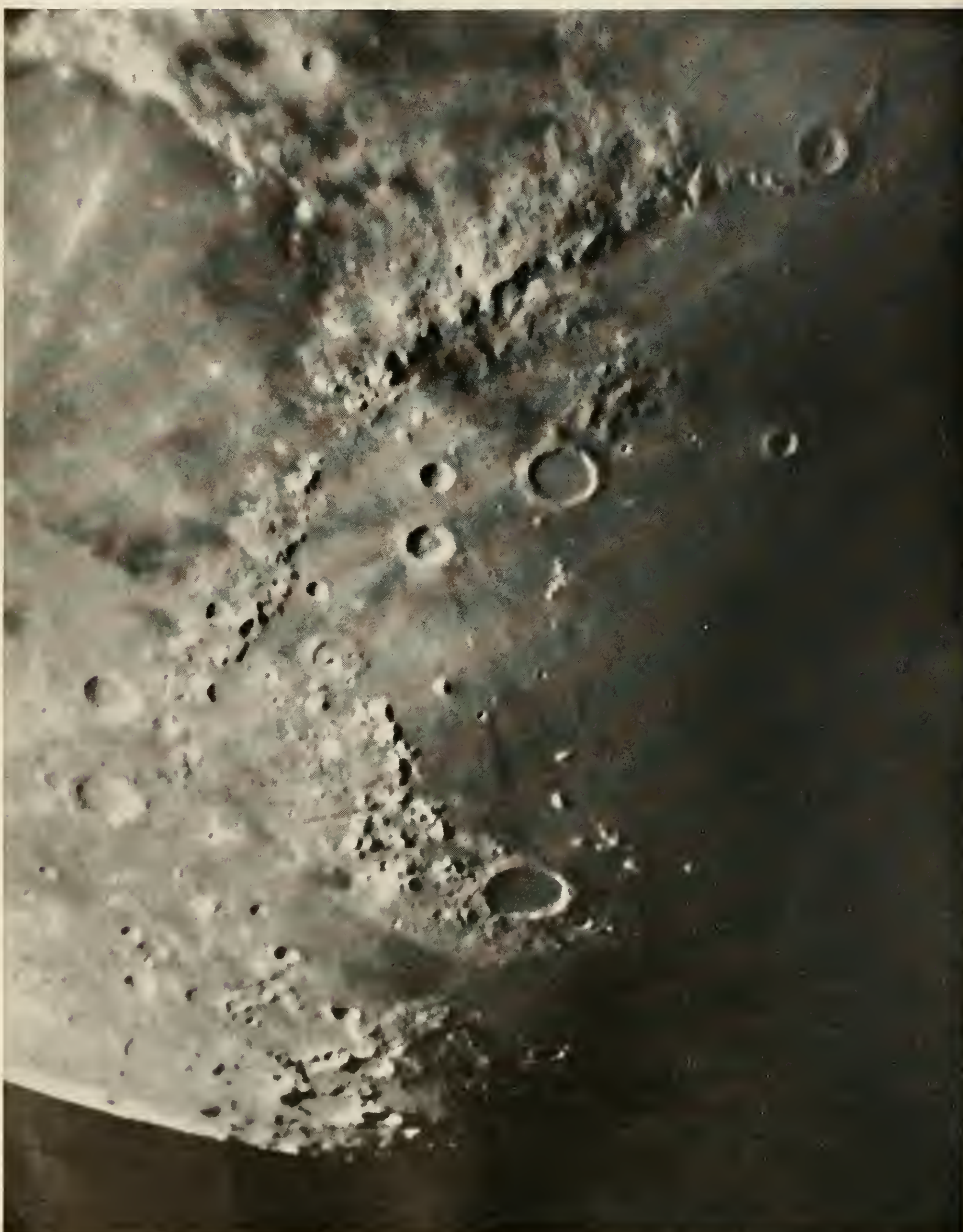

Reviews

"Culture" by the pound

By Christopher Gerould

Except that the merchandise is not hung on hooks, bookstores in the 1960's are coming to resemble the walk-in freezers of expensive butcher shops. Currently, a large public seems ready to lay out from two to ten dollars a pound for almost any volume, so long as it has color plates and a title pretentious enough to justify its mass: "The Mouse in History" might not go, but surely someone is planning "Elephants Through the Ages" for a spring list.

Reviewing books of this kind presents special problems. Their very success indicates that they have intrinsic merit or attractiveness, but their virtues are not those of a "book," as that word is usually understood. Though many of them have extensive texts, internal evidence suggests that few buyers are expected to read them. Again, the attention given by publishers to illustration might be taken to indicate that these are chiefly picture books, but closer examination argues that this is not the case either. After examining half a hundredweight of the current output, this reviewer has reached a tentative conclusion about these books' buyers. But, before stating this hypothesis, let us look at four such books that may interest readers of Natural History.

The Dawn of Civilization (McGraw-Hill Co., $28.50) is approximately eight pounds of prime, center-cut archeology, edited by the British archeologist Stuart Piggott and "written" by a total of thirteen other academically respectable authorities. This volume exhibits a standard characteristic of its breed: it carries a masthead listing five editors and sixteen other collaborators—responsible for design, art work, maps, and photography.

Presumably it takes such a team to construct a tome whose title page claims there are "940 illustrations, 172 in color, 110 original reconstructions, 645 photographs and drawings, 48 maps and chronological charts," the engravings for which were made by seven different firms in England, Germany, and Switzerland. The book also is said to contain "225,000 words," presumably including captions.

Taken altogether, this spells "the first world survey of human culture in early times," according to the jacket. The coverage is certainly extensive. The outline essays that make up the book's thirteen chapters range from the Paleolithic to the civilizations of the New World. In appearance the volume is downright sumptuous. Most of the drawings and some of the photographs are excellent, and the reproduction is uniformly magnificent. The text is beyond the reproach of any but a specialist. Yet, judged as a *book*, the whole project is a flat, rather sleazy, failure.

In the first place, the producers have come up with a physical structure (more than 400 pages, each almost 11 by 14 inches) that can only be examined at a table or lying stomach-down on the floor—a cavalier disregard of the average reader and his habits. The designer has also elected to print the texts of his eminent authors on rather handsome sheets of refined oatmeal (Apex Smooth Buff) in double columns totaling 1,400 words to the page. Thus, eyestrain is added to postural insult. Presumably in the interests of statistics, the designer has also embedded his pictures in a matrix of long captions (or possibly the reverse). Whatever the purpose, the effect is at once to kill the picture and smother the description.

Probably by design, the illustrations given the best treatment are the "110 original reconstructions." These are the sort of competent, hack paintings of "how it looked at the time" formerly much favored in historical books for younger children. The "confectors" of *The Dawn of Civilization* obviously rate them rather high. On the gatefold spread devoted to Paleolithic cave paintings, a pair of color details from Altamira and Lascaux are subordinated to a two-page chromo of a hypothetical cave ritual.

With text too truncated for reference and too crowded for survey reading, with illustrations casually selected and poorly presented, *The Dawn of Civilization* is all package and no content.

The Epic of Man (Time Inc., $13.50) carries a far smaller weight of pretension in covering much the same ground, and is correspondingly more successful. A 300-page collection and expansion of a series of *Life* articles on early cultures—with some primitive, present-day societies thrown in—it is written and presented in the bright, innocent tones of popular journalism, with an unerring eye for the specific and the trivial.

Considering its magazine-article ori-in, one does not expect a text that can e read connectedly. Nor, despite a stag-ering roster of experts who have been nsulted, is the text—as is *Dawn's*—ritten by the specialist concerned. But ord and picture at least work together ere, and one is allowed room to look at e pictures as pictures. The editors of *pic* also offer numerous "reconstruc-ons" as a crutch to their audience's im-gination. These are possibly a little orse than those in the *Dawn* book, but ite as easily forgettable—leaving only faint wonder that prehistory could have reshadowed both Walt Disney and *layboy* with quite such sentimental, not say sensual, fidelity.

Another prolific publisher of such rge, economy-size book packages has cently presented *The American Herit-ge Book of Indians* (American Herit-ge, $15). Inevitably, the work is "by" e Editors of American Heritage—a edit line that conjures up the image of platoon presumably writing round bin, a page at a time. Farther down the le page, the "narrative" is credited to illiam Brandon. The editors were cky to have someone so competent do e bulk of their work for them. Bran-n's text covers the history of the In-ans on both of the American continents. is makes it fascinating reading—in-rmed and, above all, interested and gaged in the glorious and sordid story tells. It may never be told better.

The remainder of the book is an in-larding of picture stories, to some de-ee illustrating the text. The pictures e contemporary wherever possible and osen with a very sure eye. Reproduc-n, unfortunately, is mediocre. To the ader, these interjected blocks of pic-es, with their own text and captions y prove disproportionately annoying ike shrimps in a dish of strawberries. e editors, however, cannot be severely med: no one has yet found the secret an economic way to integrate words d pictures in book publishing.

Co-operating editors have been at work again in the *Life Pictorial las of the World* (Time Inc., $30.00); s time the editors of *Life* and of Rand Nally. For once, the collaboration is y to segregate. What isn't maps is iously *Life*. What isn't maps also ves pretty irrelevant to the work.

Ours is a big world and 104 pages of otographs, though they bulk up a book ely, can hardly do much more than to w that different places look different. *Le* is also presumably responsible for ch of the general text, the slickness which underlines its inadequacy. Ex-

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Mr. Gerould, a reporter of science or many years, regularly contributes ook reviews to Natural History.

ample: Southern Europe—Spain, Italy, Greece, and Turkey—gets 400 words o text and six picture captions.

One is left, then, with maps and a gazetteer—which, basically, is what an atlas is all about—plus some pictoria diagrams. Cartographers can and have dealt with the technical shortcomings o Rand McNally's contribution to thi "new and entirely different kind o atlas." To the layman, the most immedi ate and appalling fact is that the map are so commonplace. For Canada and the United States—the only parts of the world in this *Atlas of the World* that are mapped in province and state detail—we find the same flat, familiar, straw-colored surfaces, fly-specked with town names. Accompanying inset maps—some show ing relief and vegetation, and other highlighting economic geography—are certainly a partial innovation and im provement. But, with their dark base colors and limited political information the terrain maps are not easy to read while the economic ones mix eye-aching tints and complex, multiple symbols.

These two parts of North America oc cupy half the display pages in this atlas. The rest of the world, perforce, make out for the most part with only relief and-vegetation maps—nearly hopeless for a small country like Greece and no easy to use even in the two-page map al lotted to the British Isles.

But there is, both sets of editors wil protest, much more. Indeed there is. In terspersed photographs of the Berman Fagg relief globe, a handsome objec that does not photograph particularly well; all sorts of little diagrams and charts, giving unsystematic nuggets o geographical information—in sum, just about what any old atlas has to offer. In effect, what has been added is whipped cream and a cherry. And sometimes the cream—despite the experts' efforts and those of a hoard of competent research ers—is simply sour. One example is an elegant aerial photograph (in the sec tion on the northeastern U.S.) that car ries a caption that will mislead any landlocked citizen into believing he is shown the *whole* of historic Nantucket Island—50 square miles!—magically shrunken to a dirt road, a single beach shack, and a lighthouse.

EARLIER, a hypothesis was promised regarding the current popularity o all such heavy, expensive books. This hypothesis is brief, sad, and not even profound. Since the "culture-hungry" American public is increasingly con fused by the difference between owning a book and mastering it—and since, more often than not, a person's "culture" is judged by what books he has lying abou on his coffee table—obviously the trend is to buy the most expensive (and expen sive-looking) books one can afford.

One of the most striking prints by a member of the Cape Dorset Eskimo community—and typical of free play of imagination—is this stone cut, aptly called "The Enchanted Owl."

Artists of the North

Among the Eskimos, observation combines with imaginatior

By Edmund Carpenter

For thousands of years, men have lived in arctic Canada, north of Hudson Bay. It is a hard land. The earth never thaws. Little or nothing grows. The struggle to survive is intense. Yet, when life there is reduced to barest essentials, art turns out to be among those essentials. To Eskimos, art is more than just an object: it is an act of seeing and expressing life's values — a ritual by which patterns of nature, and human nature, are revealed by man.

As a carver holds an unworked ivory tooth lightly in his hand, turning it this way and that, he whispers, "Who are you? Who hides there?" And then: "Ah, Seal!" He rarely sets out, at least consciously, to carve any particular subject, but examines the ivory to find its hidden form. If this is not immediately apparent, he carves aimlessly, humming or chanting as he works, until he sees the form. Then he brings it out: Seal, hidden, emerges. It was always there; he did not create it: he released it; he helped it step forth. What emerges from the carving is not simply seal, but an artistic act that explicates, with beauty an simplicity, the meaning of life to the Eskimo.

In the Eskimo language, little distinction is made be tween nouns and verbs: all words, in effect, are forms o the verb "to be," which itself is lacking in Eskimo. Eskim is not a nominal language; it does not simply name thing that already exist, but rather brings things and actior (nouns and verbs) into being as it goes along. This ide is reflected in the practice of naming a child at birtl When the mother is in labor, an old woman stands by an recites as many different eligible names as come to he mind. The child comes out of the womb as its name called. In this manner, the naming and the birth of the ne being are inextricably bound together.

The environment encourages the Eskimo to think in th fashion. To Western minds, the "monotony" of snow, ic

Chairman of the Anthropology Department, San Fernando Valley State College, California, DR. CARPENTER has made several extended visits among the peoples of the Arctic.

ınd darkness can often be depressing, even frightening. Nothing in particular stands out; there is no "scenery" in he sense in which we use the term. But the Eskimos do not see it this way. They are not interested in scenery, but n action, existence. This is true to some extent of many people on this earth, but it is almost of necessity true or Eskimos: nothing in their world easily defines itself or is separable from the general background. Whatever exists, the Eskimos themselves must struggle to bring into existence. Their world has to be conquered with each act and statement, each work of art or song. But, each act accomplished, it is as quickly lost. The secret of conquering a world greater than himself is not known to the Eskimo. But his role is not passive. Man is the force that eveals form, the force that cancels nothingness.

LANGUAGE is the principal tool with which Eskimos make the natural world a human world. Their many words or "snow" permit fine distinctions, not simply because hey are much concerned with snow, but because snow akes its form from the actions in which it participates: ledding, falling, igloo-building, blowing — distinctions ossible only when experienced in a meaningful context. Different kinds of snow are brought into existence by the Eskimos as they experience their environment and speak. And as a man speaks, not only is his language in statu ascendi, but so, too, is the very thing about which he s talking. Words are like the knife of the carver: they release the idea, the thing, bringing it into consciousness.

The form that the carver reveals should be beautiful. But, since that form participates in a real situation, the carving is generally utilitarian. One very characteristic Eskimo expression means "What is that for?" It is most requently used by an Eskimo when he finds some object nd stands looking down at it. It doesn't mean "What can use that for?" but something closer to "What is that intended to be used for?" The portion of an antler that so perfectly fits the hand, and gives a natural strength as well, becomes, with slight modification, a chisel handle. Form nd function, revealed together, are inseparable. Add a ew lines of dots, or incisions, rhythmically arranged to ring out the form and the tool is finished.

No primitive artists have experimented more daringly with material and form than have the Eskimos. One nineteenth-century ceremonial mask is simply a circular wooden disk—nothing more. Yet, somehow, it conveys the most subtle human expression. Complex, mobile affairs, sed in the same ritual, resemble Picasso's compositions, issected and then reassembled in three dimensions. Some Dorset carvings, dating from 700 B.C. to A.D. 1300, and Thule carvings, dating from A.D. 1200 to 1700, are no larger han a match-head, and yet so detailed that it is possible o tell a red-throated loon from a common loon. One carving of a gull weighs less than a sixtieth of an ounce.

When spring comes and igloos melt, the old habitation ites are littered with waste that includes beautifully designed tools and tiny ivory carvings—not deliberately hrown away but, with even greater indifference, just lost. For the Eskimos esteem the artistic act, not its products.

"The Archer," taken from a sealskin stencil, shows how realistic observation may be modified by artist.

Bird at center breaks symmetry of "Flight of Birds," revealing Eskimo's sophisticated sense of design.

Almost surrealistic, "X-ray" style of print is seen in this stone cut, entitled "Vision of Caribou."

This study of three walruses, at repose on the water's surface, has even captured the refraction of light.

This "Young Curlew," taken from a sealskin stencil, has something of the delicacy of an Oriental print.

Recently, Hudson Bay artisans have produced both stone carvings (Natural History, February, 1960) and prints for the outside world. They have been trained by a white man, James Houston, but they have brought to these enterprises their own delight in creating, as well as their skills and an intimate knowledge of animal life.

In print-making, two techniques are used: stone cut and sealskin stencil. To make a stone cut, the artist chips flat the face of a chunk of steatite, files it smooth, and polishes the surface by rubbing it with seal oil. He then carves the soft stone in low relief, in the manner of a woodcut; inks the surface; and transfers the image to fine paper by gently rubbing it with either his fingers or a small tampon. Finally, he peels the paper from the stone. The other technique transfers the design to a piece of sealskin. This is cut out, the resultant stencil is placed on a sheet of paper, and the ink is then brushed into the openings. Only a limited number of prints is taken from each of the original stone cuts or sealskin stencils.

Both the stone carvings and the prints closely resemble Houston's own art work, but the prints, curiously enough, share much with earlier native Eskimo art. I say "curiously," for the techniques are ones learned by Houston in Japan and taught to the artisans at Cape Dorset. But in early times Eskimo artists worked on flat surfaces, as when they etched figures on bow drills, and these new prints resemble the earlier etchings. Traditionally, too, Greenland Eskimo women cut out and intricately married dark- and light-colored skins to decorate their clothing. The Baffinlanders also made masks in this fashion.

The print-makers, like their forebears, depict not alone what the eye sees but what all their senses know: they portray mythical beings and dream experiences, an "X-ray" technique revealing what is concealed from the eye.

Here, then, is a world of chaos and chance, a whirl of cold and white. Man alone can give meaning to this—its form does not come ready made. The Eskimos, through art, transform this world into one of order and beauty. Their work not only invites our wonder: it reminds us that man makes his world livable by releasing its hidden forms.

A commonly observed phenomenon, rhythmically arranged, produces this print, called "Sea Gulls on Arctic Ice."

Typical of stylized nature of some prints are these "Birds from the Sea," rendered as decorative forms.

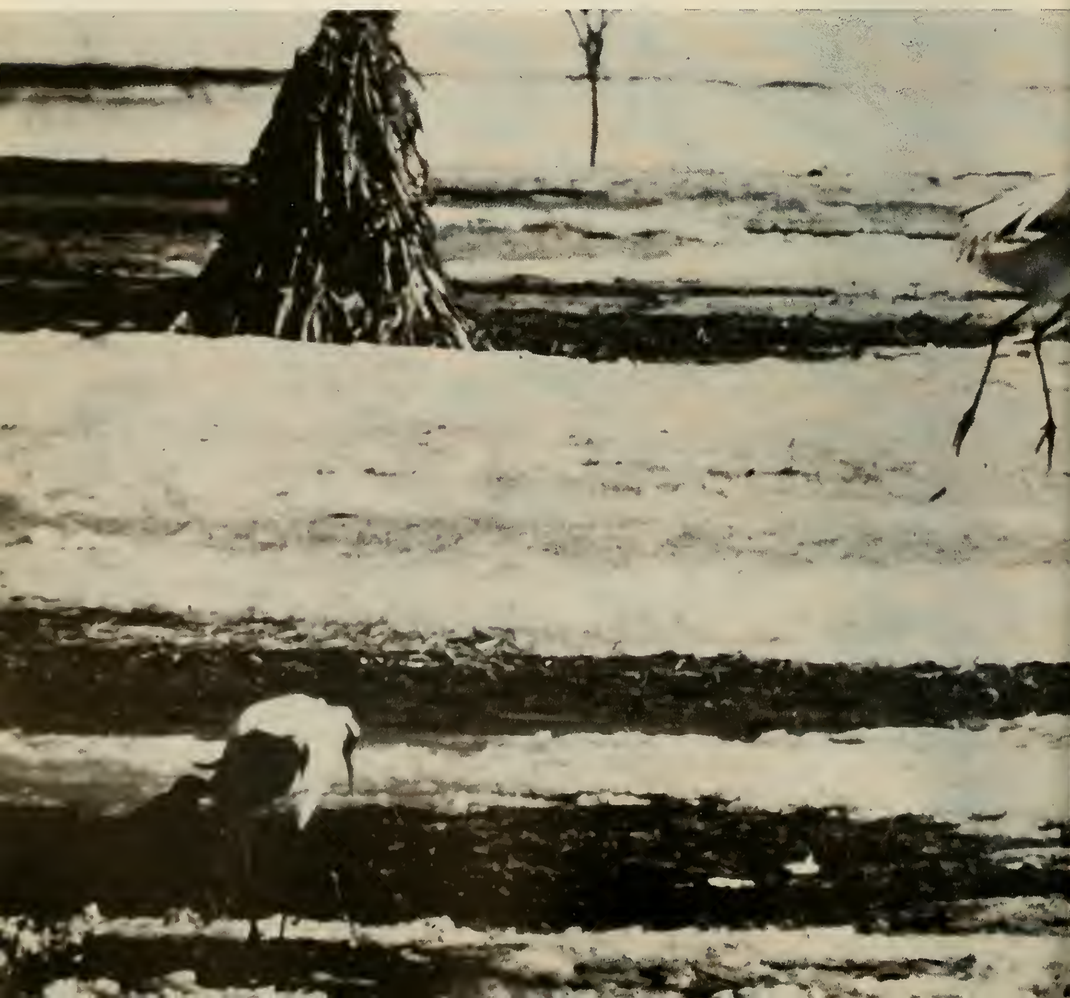
The Dance of Tanchō

The dance of the cranes, one of the most spectacular performances in all the bird world, has long excited man's imagination. E. A. Armstrong says: "To primitive men the cranes were something more than symbolic of the returning spring; they brought it. They were the surrogates of the resurgent sun-god, bringing warmth and fertility in their train."

Today, ritual crane dances survive in many parts of the world, and the Ainu have a circular dance in imitation of the bird that figures so prominently in Japanese mythology and art —Tanchō, the Japanese crane.

Grus japonensis, the Japanese or Manchurian crane, was formerly found as a breeding bird in Manchuria, neighboring parts of Siberia (Ussuri, Amur), and also throughout much of Japan. Today, some of the birds are still found on the Asiatic mainland, but in Japan, after the Meiji restoration in 1868 (when the Buddhist taboo on the killing of animals was lifted), the birds were exterminated throughout most of their range. Only one small colony now remains, confined to the vicinity of a vast marsh in eastern Hokkaido. The birds are now strictly protected, and under this protection they have rebounded from a low point of 20 birds in 1924 to about 180 in December, 1960.

The cranes nest in the marsh along



The rituals of courtship are observed in the last colony of Japanese cranes

By G. Stuart Keith

Mr. Keith, now an associate in The American Museum's Department of Ornithology, is an Oxford University graduate in the classics. He and his wife, who made the photographs that appear here, are now in Africa where they are studying local crane species.

the lower reaches of the Kushiro River. This marsh is almost impenetrable; the mud and water are too deep to wade through, and dense reeds prevent access by boat. It was here that the last remnants of the population managed to hold out until they were given official protection.

Outside the breeding season, practically the whole crane population spends the fall and winter in the vicinity of some small villages about twenty miles to the west of the Kushiro marshes. Here they have become very tame. Far from shooing them away, the local farmers welcome them on their lands, and several farmers even scatter corn for the birds each day.

Although sporadic dancing can apparently occur throughout the year—as with many other cranes—this becomes intensified in January and continues until late March, at which time the paired birds leave the wintering grounds and head for nearby marshes.

I have been using the word "dancing" rather loosely to refer to the action of leaping in the air and flapping the wings—an action that, in fact, is performed in a number of different behavioral situations. Perhaps the best-known of these is when two birds of a pair dance together. We may call this courtship dancing, although it is performed anew each spring by birds that may have been mated for many

Dancing bird picks up corn husk with bill and throws it in the air. In other species, thrown objects may be sticks, paper, or other nest-building materials.

years. The dance may begin quite suddenly. A pair of cranes are feeding quietly in a field; all at once one of them looks up, turns to face the other, and starts bowing. In this bowing—or "head-bobbing," as I call it—the head is held horizontally, the neck curved down in a U, and in this position the head and neck are bobbed or pumped up and down. The second bird stops feeding, looks up, and may then start head-bobbing in the same way, facing its partner. If it does not join in at once, it will, at any rate, hold its head erect in an alert position, watching its partner with apparent interest.

Then the first bird, while continuing to bow, will start flapping its wings a bit, and with a few light, dancing steps will turn around several times on the spot. With each turn, the pace increases. Finally the two birds square off and start jumping into the air and flapping their wings. After each jump, the left leg—which is held slightly higher than the right—gives an extra kick in mid-air. At the top of the jump, which may be six or eight feet high, the birds hold their wings outspread and seem to float on air for an instant.

Sometimes, after an especially high jump, the birds may make a brief dance-flight; side by side they plane gently down, still seeming to float in the air, and may come to rest 25 or 50 yards from where they were dancing. After such a dance-flight, which by no means occurs with every dance, the performance usually stops, although a few more leaps may occur. Then the birds resume their feeding.

Two other components of the courtship dance must be described. The first consists in picking up some object from the ground with the bill and tossing it into the air. In the case of the Japanese cranes, this was usually a corn husk, many of which were lying in the field. Other cranes have been seen to pick up sticks, grass, and pieces of paper. The objects the cranes pick up are the sort that might be used in nest-building (the paper was used by a captive bird). It is possible that the picking up of corn husks may be a displacement activity, resulting from the conflict of two inner drives, but it may also be that this action is related to nest-building drives and the presence of specific stimuli related to nest-building, such as suitable nest material.

Second, during the dance one bird may turn its back on the other and continue to leap up and down, spreading its wings out fully. This achieves the effect of displaying the wing's black secondary feathers, which flash out in striking contrast to the rest of the white wings and back.

Finally, it should be mentioned that the courtship display remains largely a silent affair, although the birds may sometimes call, especially just after the dance. This contrasts with the duet display and much of the communal dancing, described below, which is often accompanied by calling.

So much for the courtship dance, performed by male and female. More difficult to understand is the communal dancing, in which more than two birds take part. When two cranes in a flock start to dance, this often arouses the surrounding birds to join in, and a dozen birds may all be leaping in the air at once. Some of the other members join in wholeheartedly, leaping up and flapping their wings; some only give a few desultory hops; others just stand and watch, while those farther out may continue feeding or preening without reacting at all. Generally, those closest to the original dancers react the most vigorously, as might be expected. The bystanders who join in the dance do not aim their dance at their mates or at rivals, but at no one in particular. Perhaps, with cranes, dancing is infectious, just as laughter is with us.

Such is the reaction of cranes to the visual stimulus of other cranes dancing. Often, however, one or more birds in a flock may leap in the air without any such stimulus. When two birds jostle each other while feeding, one or both may leap in the air; a bird may take a leap when other birds land near it; or a leap may be the reaction to an aggressive lunge by a neighbor. Sometimes a bird slightly apart from the flock may start leaping up and down on its own, seemingly without having been stimulated by the action of any other crane.

This leaping in the air, then, which may or may not involve wing-flapping,

Key display of its black wing feathers is achieved by this dancing crane that has here turned its back on its partner.

Two birds posture at left at the beginning of their duet display, under the eyes of non-participating birds at right.

Three birds in feeding flock, *below*, suddenly begin to call and dance in an apparently unmotivated burst of action.

eems to be an almost involuntary re-ction to a variety of stimuli—or to no pparent stimulus at all. Robert Peter llen, discussing similar perform-nces among sandhill cranes, suggests iat the constant jumping and wing-apping may be partly the result of a ighly nervous and emotional condi-on brought about by the develop-ent of the gonads. This would not ccount for dancing outside the breed-ig season, but may well explain the eightening of activity in the spring, which season the threshold of re-ponse to the stimuli that release danc-ig is unusually low.

THERE are times when the drive is so strong that dancing will take ace without any releasing stimulus. his is a strong statement to make, nce one always has the uneasy feel-ig that there *might* be some stimulus f which one is not aware that releases ie behavior. But Lawrence Walkin-iaw gives a fascinating account of a oung sandhill crane that he raised om a day-old chick. When it was nly five days old it started leaping o and down and going through two her actions of the dance—bowing nd tossing objects into the air. This ird had never seen another crane which shows, incidentally, that the attern or form of the dancing is in-ate), and I think this is an example f what has been called "vacuum ac-vity," or activity that results when an ner drive builds up to such a point iat it just "goes off" in the absence of releasing stimulus. Among people, e call it "letting off steam." I think iat some of the solo dancers among ie Japanese cranes may just have een "letting off steam," even though it could be argued that there were always other cranes in sight that might have released the dancing.

Aside from the dancing, Japanese cranes have another fascinating type of behavior, which I call the "duet display." At its onset, one bird starts stalking stiffly around in front of another, its neck held erect and its head bent down until its beak is pointing at its chest, like a horse on a very tight rein. This serves to display the patch of red on top of the head. The wings of the displaying bird are just slightly raised, as are those of the bird being displayed to. The latter stands stiffly at attention during this part of the performance, and may take a few steps. After a time, the first bird walks up to the other, raises its wings higher off its back, throws its head up until its beak is pointing to the sky, and starts calling. The other bird adopts a similar posture, raises its wings and calls, and the two may continue calling thus for ten or fifteen seconds. They make a very beautiful picture—two majestic birds standing side by side and calling their duet together. When they finish their calling, the performance has been completed.

One of the principal problems in studying all crane behavior is the extreme difficulty in telling males from females. There is no plumage difference and no appreciable size difference, and I could not tell which was which. To add to the confusion, Jean Delacour tells me that the female initiates displays more often than does the male. However, he adds that when his captive pair of Japanese cranes performed the duet display, both birds raised the wings slightly off the back while calling, but that, in addition, the male lowered and spread the primaries, whereas the female kept them folded into the rest of the wing. My motion pictures of a duetting pair also show this action, with only one of the birds lowering the primaries, spreading them in a way that is reminiscent of a fan being opened. Apart from this, about the only way of identifying a male crane is by its more aggressive, more "male-ish" behavior.

When the Japanese cranes come together in a flock, a good deal of aggressive behavior takes place, and there is obviously some kind of established hierarchy among them. In one observed case, the weakest bird, which was lame in one foot, was pecked at by the others but never pecked back in return. Young birds of the flock were similarly bullied.

AGGRESSIVE display against a neighbor can be either of the "arched over" or "arched under" type (shown below). Both serve to display the red patch on top of the head. If these postures fail to impress the threatened bird, or if it fails to back away fast enough, a short run and a lunge with the beak, accompanied by a hiss like that of a goose, follows. The run is short because the adversary always backs away in time; I never saw a bird actually make contact, nor an opponent stay to fight. Often a simple threat posture is enough to send the other bird running.

Many problems remain to be solved concerning the behavior of the Japanese crane. Study of the birds at the nest should shed some light on these problems, and if the birds expand their range into areas where nests are accessible, I hope to study them again.

GGRESSIVE BEHAVIOR, which aids in establishing some kind f hierarchy in the flock, takes two forms: bird at center postures in "arched under" pattern in threatening bird at left; "arched over" position is shown in bird at far right.

Sorcery, Religion and the Man

Forms of magic can be social tools for solving some problems

By Philip Newman

Man has created many forms in his quest for means of dealing with the world around him. Whether these forms be material tools, social groups, or intangible ideas, they are all, in a sense, "instruments": each is a means to some end; each has a purpose that it fulfills. When we think of such things as magical rites, a belief in ghosts, or accusations of sorcery, however, the matter of purpose becomes less obvious. In the descriptions and in the case history that follow, we will try both to show something of the magical and religious beliefs of a New Guinea people and to demonstrate the purposes that these beliefs have for the men who hold them.

In the mountainous interior of Australian New Guinea, the Asaro River has its headwaters some thirty miles to the north of Goroka, a European settlement that serves as the administrative center for the Central Highlands District. Near Goroka, the Asaro flows through a wide valley where the ground cover is mostly grasses and reeds. In its upper reaches, this valley narrows into a gorge where steep, heavily forested ridges reach out toward the river from mountain masses on either side. Some 12,000 people live on this part of the river, occupying an area of approximately 200 square miles. While these people are culturally and linguistically similar, they do not form a single political unit. Indeed, before contact with Europeans, the area was characterized by incessant intertribal warfare. Even now, when active warfare is no longer part of their lives, the pattern of alliances

Upper Asaro men regularly gather wood for building, hunt birds and mammals, and collect plants for food and medicine.

Standing apart from other village houses is men's house, *above*, which can be distinguished by its multiple roof poles.

and animosities among the tribes is a factor in social intercourse.

Except for the cessation of warfare, life in the valley today is little changed from what it was before the Australian government began active pacification of the area after the end of World War II. Almost daily, the people climb up from the valley floor to enter the dense forest on the mountain slopes. It is here that building wood is gathered; birds and small marsupials are shot for meat, plumage, or fur; plants that provide for many needs are collected.

Below an altitude of some 7,000 feet, the forest has been cut back to make room for gardens that cling to the sides of steep ridges and crowd together in the narrow valley floors. These gardens provide the people's staple foods—sweet potatoes, yams, sugar cane, and a variety of green vegetables. A woman spends most of her time at garden work, preparing new planting areas, weeding the crop, and harvesting mature plants. In fallow areas nearby she can turn loose the pigs her husband has entrusted to her care. If they wander too far afield by evening, her call will bring them back on the run. They know that a meal awaits them, as well as a snooze by the fire in their "mother's" house.

While each family may have one or more houses near the forest or in their garden, the center of social life is the village. The villages are located on the tops of ridges in spots usually selected with an eye to their defensibility against enemies. The fifteen to twenty houses that compose each village usually march in single file along the narrow ridge. But, if space permits, they are formed into a square. All the houses are much alike—round, about 15 feet in diameter, made of double rows of five-foot stakes. The space between the stakes is filled with grass and the outside covered with strips of bark. The roof is thatched and topped with a long, tasseled pole.

Two or three houses always stand out. They are larger, they are not in line with the rest, and they may have as many as eight poles protruding through their roofs. These are the men's houses. As a rule, men and women do not live together, for the men fear that too much contact with women is weakening. For this reason, a man builds a house for his wife—or each of them, if he has more than one —and then helps in the construction of the larger house where he and the other men of the village will sleep apart. Ideally, all the men who live together in a single house can trace their descent back to a known, common ancestor. They thus constitute a lineage. Such a lineage is connected to the other village men's houses by descent links, but in many cases the links are so amorphous that no one can actually tell what they are. Similarly, several villages will be linked together into a clan, but geneological ties may be more imputed than real.

Just as the forest and the garden represent the physical framework within which each individual lives, so too these various orders of grouping—the lineage, the village, the clan, and the tribe—represent the social framework of existence. The members of these groups are the people with whom each individual is in daily contact. They nurture him, teach him, and assist him in times of crisis. It is from these groups that he derives such things as his name, his rights to the land for gardening and hunting, and the financial help that he needs when it is time to purchase a wife. They hail his birth and mourn his death.

In turn, each individual has obligations to the other members of these groups. He acts as a representative of his group when dealing with outsiders. In this way, he enters into a whole series of relationships with individuals and groups outside his own immediate circle. He may visit a neighboring clan to help one of his own clansmen win the admiration of a prospective bride by sitting up all night near the hot fire singing love songs to her. Or a trip may take him to a nearby tribe, where he dances mightily with other men to show that his group is appreciative of the gift of food and valuables they are about to receive. He may walk several days over difficult ground to reach a completely alien group, where he can barter for shells, plumes, or foodstuffs not available in his own group. As in all societies, the groups comprising the society provide for the individual, while the individual, in turn, contributes some of his efforts to the life of the group.

An Ogden Mills Fellowship, after a trip to Australian New Guinea, has allowed Mr. Newman to work up the results of his field studies there. He is with the anthropology department at the University of California.

Man not only has his tools and his society to help cope with the world: he also has his ideas. There are some problems presented by the environment for which the people of the upper Asaro have not yet devised a mechanical or technical solution. There are other problems for which a technical solution seems not enough. Finally, there are problems for which an idea seems to be an inherently better solution than a physical or social tool. It is here that we enter the realm of magic and religion.

A great many of the activities among the upper Asaro people have a magical or religious component. When a child is born, it is cleaned, fed, and covered with grease to help protect it from the cool mountain air. It is also protected, non-physically, by burying its umbilical cord in some secluded spot—so that sorcerers cannot later use this piece of the new-formed being to cause illness or death by magical means. During the first few days of life, the infant is also made to accept, via magic, his first social responsibility—not to cry at night and disturb its mother. A small bundle of sweet-smelling grass is placed on the mother's head and her desire for uninterrupted slumber is blown into the grass by an attendant. The grass is then crushed over the head of the child and its pungent odor released so that the infant will breathe in the command along with the scent of the plant.

Throughout an individual's life there will be magical rites to protect him from various dangers, to overcome difficulties, and to assist his growth. When a young boy kills his first animal, his hand will be magically "locked" in the position that first sent an arrow on a true course. When he reaches puberty and moves out of his mother's house to begin his life in the men's house, he will be ritually cleansed of the contamination he has been subjected to during his years of association with women. If he were not so cleansed, he would never become strong enough to engage in men's activities. During the years when a young man is trying to win the favor of a girl, he not only relies on his prowess in singing love songs and his decorations, but on his knowledge of love magic as well. If all the usual spells and potions fail, he may utilize one especially powerful form that is thought to make him appear to his be-

loved with an entirely new face—the face of someone he knows she likes.

In his mature years, when a man's attention turns to the growth of pigs and gardens, he will have magical as well as technical skills to help him. Gardens are not difficult to grow in this fertile land, but it is still wise to put a certain series of leaves across one's fences, so that any thief will find his arms and legs paralyzed should he decide to raid the garden. It also behooves one whose gardens are near the main trails and settlements to give them magical assistance, for a slow-growing garden in such a conspicuous place could be an embarrassment.

The raising of pigs is a more difficult matter, and it is here that magical and religious rites become greatly elaborated. Some of these rites are performed by an individual for his own pigs. It may be a simple performance, as when smoke is blown into the ear of a wild pig to tame it. The theory is that the smoke cools and dries the pig's "hot" disposition. On the other hand, these individual rites may attain considerable complexity, as in the propitiation of forest spirits called *nokondisi*. These spirits are capricious in nature—sometimes playing malicious tricks on men and sometimes performing acts of kindness. Each man, therefore, maintains a small, fenced enclosure in which he builds a miniature earth oven and a tiny house. By placing food in the earth oven he may be able to entice a *nokondisi* to come live near his pigs and watch after them. In return for the food, the spirit will help bring in lost pigs, protect the herd from thieves, and carry the animals safely across flooded streams during the rainy season.

In addition to the magic performed by an individual on behalf of his own pigs, some rather elaborate rites are performed by the lineage and clan for all the pigs belonging to these groups. The largest of these is the *gerua* ceremony, performed at intervals of from five to seven years. In this ritual, hundreds of pigs are killed and used to pay off various kinds of economic obligations to other clans. It is a time for feasting and dancing, for courting and reunion. It is also a time for propitiating the ghosts of the dead in the hope that they will help the living grow their pigs. All the pigs are killed in the name of particular ghosts. The songs are pleas for ghostly assistance. The wooden *gerua* boards, with their colorful geometric designs, are visible symbols to the ghosts that they have not been forgotten. It is not tender sentiment that motivates this display, however. Rather, it is the fear that failure to do so will engender the wrath of the ever-watchful dead.

The magical and religious beliefs that we have so far examined are all used in conjunction with other prac-

In its lower reaches, the broad Asaro Valley stretches to the south. The ridges extending into it from east and west are the lands of the Asaro people, whose gardens and villages are cut from forests below the 7,000-foot level.

FRAGRANT GRASS, transferred from head of mother to that of baby on her back, is assurance that infant will not cry.

PROTECTION AGAINST RAIN is undertaken by two men putting a magical "fence" around this public ceremony to prevent a

tices of a non-magical nature. There are some areas, however, where no purely technical solutions are available, and where magic and religion are the only "tools" available. One such area is sickness. The people of the upper Asaro are not generally aware of modern medical practices, although efforts are being made in that direction. The non-magical techniques available to them, such as inhaling the steam from fragrant plants to relieve a stopped-up nose, are few. These remedies do not extend to more serious maladies. When serious illness strikes, the only recourse is to magic.

The magical solutions available are many and varied. There are herbs with magical properties that are administered in much the same way as are medicines in our own society. I made a cursory check, however, which seems to show that few of the plants possess any curative value.

Ghosts and forest spirits are frequently thought to be the causes of illness, for they are deemed capable of entering the body and devouring a person's inner organs. Cures for such illnesses usually involve propitiation of the offending supernatural.

WITCHES and sorcerers are believed to be another major cause of illness, for they are supposedly capable of injecting foreign bodies into a victim, or performing black magic on objects that have been in association with the victim. To cure illness caused in this way involves calling in a magical specialist who can either extract the foreign bodies or retrieve the objects being operated upon.

While the ideas and rites listed here do not exhaust the entire inventory available to the group under discussion, they give some sense of the variety that exists. The notions are interesting in themselves, but the question of how an individual makes use of these notions is even more fascinating. Let us look at a crisis in the life of one of these people, and see how he picks and chooses among the various "tools" at his disposal.

Ombo was a young man in his early thirties. He had been married for about five years, but was childless. Early one April, it was announced in the traditional style that his wife, Magara, was with child. On such an occasion, a food distribution is held in the village and the announcement, along with gifts of food, was sent out to related villages. Ombo was instructed in the food taboos he would have to undergo during the period of his wife's pregnancy to protect himself from her increased contamination.

All went well for the first few weeks and then Magara became ill. It is doubtful that her illness was associated with her pregnancy, for her symptoms were the classic signs of malaria—a rather rare disease in this part of the highlands. The first attempts to cure her involved a variety of highly regarded pseudomedications.

threatening shower from breaking up proceedings. Often, magic is the only available means of "controlling" nature.

PRIMITIVE INHALER is used by head cold victim, who wraps aromatic leaves around hot stone and breathes in the fumes.

A potion of sweet-smelling leaves was administered. A command o the effect that the illness should de-)art was blown into the leaves, and he leaves were eaten. It was thought hat the command, thus internalized, vould drive out the illness.

At various other times, attempts vere made to relieve her headaches ind body pains by rubbing the af-licted areas with stinging nettles. It vas held that when the welts and the)ain caused by the nettles subsided, he pains in her body would also leave.)n one occasion her husband blew moke over her during a period of ever because, as we have seen, smoke s held to have a cooling and drying effect. He also painted various parts)f her body with mud in an effort to :ause the pain to dry up at the same ime the mud dried.

This kind of treatment continued intil early May without any notice-able improvement in Magara's condi-ion. After almost a month had passed and it became apparent that the illness was not going away, Ombo began to speculate on a possible cause. During the next few weeks he came up with several solutions. While he had been away from the village, working for Europeans in Goroka, he had acquired some charms to help him win at a card game popular among the sophisticated younger men.

One of these charms was fairly new and he was worried that he might not have gained sufficient control over it. Since he kept it hidden in his wife's house, his conclusion was that the charm was exerting its influence on her and causing the illness. He therefore removed it from her house and sent it away to a friend in another tribe. There was no improvement in his wife's condition.

Ombo's next action was to destroy his spirit house. He had not kept it in good repair and had not been diligent in feeding the *nokondisi* that lived there. His father suggested that the angered spirit was taking revenge on Magara. By destroying the house of the spirit, Ombo caused it to retreat to the forest where it could do no harm. Finally, he burned the costly paraphernalia of a potent sorcery technique he had purchased some years before, fearing it affected his wife.

By now it was late in May. Magara had become so ill that she stopped all but the most minimal work in her garden. Concern about her illness began to increase, and people outside the immediate family began to speculate about its cause. Ombo's older brother mentioned one day that a malevolent ghost might be behind it. It was not long after this that a meeting was held in the men's house and Fumai, a member of the lineage, recounted a dream he had had the night before. In it, he had seen the ghost of Ombo's great-grandmother sitting in the forest near the spot where *gerua* boards are displayed for the ancestors.

NEAT GARDENS cling to Asaro hillsides and extend down to the narrow floors of the valleys. From these gardens, which are solely the responsibility of the Asaro women, come all of the staple foods on which the entire community depends.

She had covered herself with ashes and, in a fit of self-pity, was wailing loudly because no one had made a *gerua* board in her honor at the last *gerua* ceremony, and no one had killed a pig in her name. Since ashes are put on at the death of a near relative as a sign of mourning, while clay is put on if the deceased is more distantly related, and since ghosts are thought to be capable of causing death, it was concluded that the dream was prophetic. It implied the imminent death of Magara at the great-grandmother's hands unless something were done.

The next day, Ombo and his wife, along with his parents and siblings, set out for the spot where the ghost had been "seen." A pig was killed there in honor of the ghost. It was cooked in an earth oven filled with valued food items—the largest sweet potatoes, the most succulent yams, and the most highly prized varieties of taro. While water was being poured into the oven, a speech was addressed to the ghost. It was pointed out that the food had been prepared and donated in her honor at considerable trouble to those present. The feeling was expressed that she should be satisfied with the amount and the quality of the offering. She was then told to refrain from causing trouble in the future. As the food steamed in the oven, a *gerua* board was made in the ghost's honor and placed among others in a nearby tree. Some of the food was eaten and the rest was later distributed among members of the lineage.

THINGS seemed to go well for the next few weeks. Magara improved and was able to return to her work in the garden. Discussion of the topic was dropped. Then, late in June, she suddenly became ill again. Ombo was greatly upset. I suggested to him that she might have malaria and should be taken to the medical aid post. But Ombo did not want to do this, for by now he was convinced that his wife was being attacked by a sorcerer. To deal with this threat, a magical specialist had to be called in. It was several days before he arrived, for he lived some distance away in another tribe. As with any good "doctor," his first acts were aimed at relieving his patient's pain and fever. With much physical strain, he literally pulled the pain from her body and cast it into the ground where it could do no further harm. His next task was to find out what was causing her illness. For over two hours he sat chatting with Ombo and Magara, discussing the history of the illness, the treatments that had been used, and their own life histories. All the while, he puffed on a tobacco pipe made of a bamboo tube. The degree of irritation caused by the smoke in his throat signalized the appearance in the conversation of significant diagnostic events.

Finally, he announced his conclusion —illness by black magic.

To eliminate the effects of the im- puted black magic, the object being manipulated by the sorcerer had to be recovered. To do this, the magical specialist first had a bundle of long, thin leaves prepared. Into the bundle were put cooked pork and a variety of plants with magical properties. The specialist never directly touched the bundle himself, but directed Ombo in its preparation. When the bundle was completed, it and a specially prepared bamboo tube were both carried into Magara's house. She was given the tube to hold and the bundle was hung in the rafters near the center pole. After a rite to protect her from further sorcery, Ombo and Magara were locked together in the house.

The specialist remained outside. He walked round and round the house, reciting spells and whirling a special plant around his head. He was pulling the unknown object away from the sorcerer and bringing it back home. The ceremony became a real struggle: the object would come tantalizingly close, only to slip away. Then the specialist announced that the object had arrived. Magara was instructed to open the bundle in the rafters. Inside, among the bits of meat, were a small spider and a piece of string of the type used to hang ornaments around the neck.

The spider, Magara and Ombo were told, was an assistant to the specialist. It had taken the string out of the sorcerer's house and into the open where the specialist could reach it with his powers. The sorcerer was thought to be a young man who had once wanted to marry Magara. The existence of a disappointed suitor was one fact that had come out during the specialist's long interview. When Magara had married Ombo, the suitor had become angry and cut a bit of her necklace string to use for sorcery. The specialist placed the recovered string in the bamboo tube that Magara had been holding, and the tube was then hidden away among the thatch.

From that time until late September, when I left the area, Magara did not experience any further attacks of illness, although she was not in the best of health. The community considered her cured. Significantly, her child was born prematurely in September and died two days later, but no one saw any connection between this death and her illness.

WHAT, then, can we say about the purpose of such ideas and behavior patterns? A situation such as Magara's creates a great deal of tension in an individual who experiences it. If magic does nothing more, it allows the bearer of this tension to act. Both the patient and those concerned feel that something is being done. The pioneer anthropologist Bronislaw Malinowski long ago made the point: "Magic expresses the greater value for man of confidence over doubt, of steadfastness over vacillation, of optimism over pessimism."

It is a rare man indeed, however, who can maintain his confidence and optimism in the face of repeated failure. The question then arises, why is it that magic is not more readily given up? Three answers have traditionally been given to this question, all of them valid. In the first place, for people such as these, there is no alternative. Secondly, for the believer in the efficacy of magic, the occasional chance successes are more significant than repeated failure. Finally, explanations for failures are always at hand. Inadvertent errors in spells or formulas that must be performed precisely, or imagined countermagic, are ready explanations that are necessarily built into the very nature of magic.

The case history we have seen suggests still a fourth answer. This answer becomes apparent, however, only if we examine the way in which an

ALMOST INVISIBLE under her load of produce, Asaro woman trudges down from her mountain garden into village.

RUBBING WITH NETTLES is believed to make other pains subside as back heals.

individual makes use of the magical notions available to him. In the progression of the various magical techniques and explanations employed by Ombo, we can see that they call for behavior patterns allowing for increasingly aggressive release of the tension built up in him by the failure of previously selected techniques.

The simple pseudomedicinal rites, such as rubbing with nettles and painting with mud, were enough to reduce the tension of the initial crisis. The treatment was symptomatic and there was no attempt to identify the cause of the illness. When it became apparent that these techniques had failed, we find Ombo resorting to the more drastic measure of destroying valuable property. The frustration was not yet great enough to cause him to seek outlets in other people: that which he destroyed and removed from his use belonged only to him. In the next phase, we find that a ghost is predicated as the causative agent. One need not be nice to ghosts. They, like the living, are thought to be a mercenary lot who do not much care what is said about them as long as they get their just due. The speech made to the great-grandmother was studded with commands and expressions of anger at the trouble the ghost had caused. This was an excellent mechanism for the release of tension, just as was the physical act of killing the pig.

FINALLY, we see the most aggressive act of all—accusing a specific individual of sorcery. The accused individual was a member of an enemy tribe and lived some distance away. It was, therefore, unlikely that accuser and accused would often meet. But if the two had come together, a fight would have been inevitable. In former times, this could have led to open warfare. Thus, Ombo not only used magic as a tool against disease, but also selected the magical tools in such an order that his own increasing anxiety was relieved by increasingly aggressive actions. It is thus not only the forms created by man that enable him to cope with the world he meets, but the very way in which he manipulates those forms that are available to him.

FOOD IS PLACED before the spirit house. It is thought this will keep spirit in house and help owner to care for pigs.

PIG-KILLING CEREMONY, *right*, is carried out by man for propitiating the ghost believed to be causing wife's illness

Dolphins and Hearing

A study of underwater sound perception

By Winthrop N. Kellogg

The oceans cover nearly three-quarters of the earth, to an estimated average depth of about 13,000 feet. They are teeming with life of all kinds. Yet what goes on in these unexplored regions is one of the greatest mysteries with which mankind is faced. In some ways, he knows less about it than he does about the stars —for these, at least, he can see. Once under water, the most important avenue of investigation—the use of visual observation—is either impossible or else is limited to a very small area close to the observer.

With the development of the science of electronics, a new technique for investigating the mysteries of the deep began to evolve. This is the method of *listening* to what takes place beneath the surface. If a man could not see what went on there, he could at least hear, and he could record the various sounds that he heard.

During World War II the problem of noisemaking in the ocean rose from relative obscurity to great importance. At that time, the method of detecting the presence of enemy ships by listening for their engine and propeller sounds began to be used. Not only were submarines equipped with the necessary apparatus to do this, but installations were also placed at important harbors along the coast to signal the approach of enemy vessels.

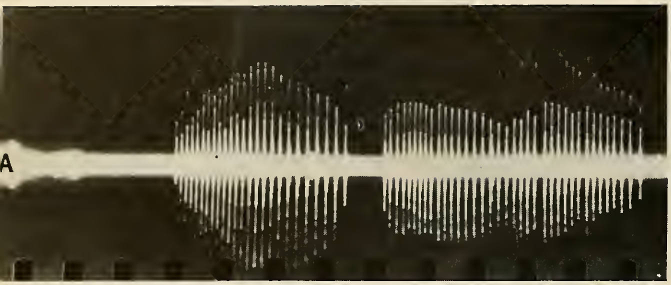
Listening equipment of this sort was set up during the winter of 1942 at Fort Monroe, Virginia, to protect the entrance to Chesapeake Bay. This was found on the whole to work well as a detecting device. In the spring, however, the loudspeakers at the stations on shore began to give off a concatenation of hammering noises, which resembled a chorus of pneumatic drills breaking up concrete pavement. In the evening, particularly, this became so voluminous that it drowned out completely any ship or propeller noises. It was found that these noises were made by schools of croakers *(Micropogon)* returning to the bay after spawning.

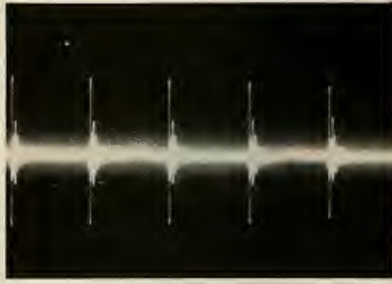
Since 1951 we have been involved with one of the most intelligent of all animals—the bottlenose dolphin, *Tursiops truncatus*. We have been attempting to answer the question of whether dolphins "see" with their ears—whether they can navigate without the use of vision, smell, taste, or touch. The whales, dolphins, and porpoises belong to the taxonomic order of Cetacea. All of them are warm-blooded, air-breathing mammals. They must continually come to the surface or they would suffocate. All give birth to their young alive and nourish them with milk. Their ancestors at one time lived on the land.

The bottlenose dolphin, in which we have been interested, is a small member of the Odontoceti, or toothed whales. Bottlenoses, which are very large, may reach a length of 10 or 12 feet, but measurements of a number of specimens taken off the Texas coast in the Gulf of Mexico show the average length in that locality to be closer to eight feet. The weight of a seven- or eight-foot animal is some 300 pounds.

Dolphins are fast-swimming animals. Although not so swift, the giant whales possess tremendous mass. In both cases, the momentum of the or-

Salt-water pool at Alligator Harbor, *left*, was author's outdoor laboratory. The two dolphins may be seen at center.





STIMULUS AND RESPONSE are seen in the scope trace, *left.* Water splash (a) elicited trains of sound pulses from the

ganism (the product of mass X velocity) is great. As a consequence, a collision with a submerged obstacle, such as a rock or the bottom of a ship, would be disastrous. Obviously, these animals must have some means of detecting obstructions in their pathway at a distance that permits avoidance.

One naturally thinks of the eye in this connection, since this is the primary organ of spatial perception in man. One complicating factor for the cetaceans is that their eyes are set far on either side of the head. This means, according to O. R. Langworthy, "that there is no opportunity for binocular stereoscopic vision." Langworthy further states: "it has been clearly shown . . . that, in the dolphin at least, all the optic fibres decussate in the mid-line for anything more complicated than panoramic vision." Panoramic vision would not be nearly so good for the accurate perception of objects at a distance as stereoscopic vision is.

Aside from this optical point, there are physical reasons why vision does not work well in water—no matter how efficient the optical organ. For one thing, coastal sea water often contains a large amount of sediment or silt. The sediment can be stirred up from the bottom by waves and currents, or it can be carried many miles into the ocean by great rivers. Even far at sea the water may be filled with clouds of plankton that, like banks of fog, drastically limit the range of vision. Further, the bottlenose dolphin is a frequent visitor in harbors, bays, and estuaries, where the water may be so turbid that visibility is limited to a few inches. A big harbor contains both moving and anchored ships, buoys, pilings, docks, and piers. How can the animal navigate amid such hazards without the risk of accidents?

Man has a method, which he is still perfecting, for navigation beneath the surface of the ocean without the use of vision. This is the method of "sonar," or echo-ranging. The principle of sonar is much the same as that of radar, except that the range and the speed of acoustical echoes are much more limited than are those of radio. Since radar will not work in water, and vision is of little use for submarine navigation, sonar is the subsurface substitute for both.

With sonar, a train of repeated sound signals is emitted by an underwater source. These signals are usually of high-audio frequency or are ultrasonic. Echoes are reflected back to the source from the submerged target. These are then translated so as to reveal both the distance and, to some extent, the shape of the target.

Now, the cetaceans are capable of producing many kinds of sounds. Observations of these noises, at least in the case of the dolphin, go back thousands of years and are in no sense modern discoveries. Thus, Aristotle writes that the dolphin "when taken out of water gives a squeak and moans in the air." And Pliny the Elder, who certainly knew of Aristotle's statement, says "for a voice they have a moan like a human being."

I have recorded *Tursiops* sounds in experiments made at Bimini, in the Bahama Islands, and at the Daytona Sea Zoo. An analysis of these recordings has shown that the most common are a birdlike, indeed, canary-like, whistle and a rapid succession of clicking or clacking pulses, which occur in series lasting several seconds or more. The noises of the common dolphin, *Delphinus delphis*, analyzed by Vincent, have also been found to contain whistles, "crackles," and mewings.

We have now to examine the question of whether any of these sounds are the sorts of noises that might conceivably be used for echo-ranging or for navigation in the sea. The question might be rephrased something like this: Do any of the noises resemble the ranging or beaming signals of man's electronic sonar?

In the case of the dolphin there is an obvious similarity—which can be recognized merely by listening—between the rapid succession of pulses (the "sputtering" sound) and the so-called pings sent out by sonar. The principal differences, which can be distinguished at once, are, first, that the frequency of emission of the animal's pinging sound varies over a wide range, whereas that of sonar is usually constant; and, second, that the intensity of the animal noises may also be markedly altered within a single burst of ranging signals.

The animal's whistle, we think, might be used in echo-ranging but there is less likelihood of this. It would be a frequency-modulated signal: since the pitch is continually changing, the returning echo at any single instant would be different from the pitch of the tone being emitted at the source. Observations of captive animals' whistles, however, suggests that the sounds are more likely to be some sort of a call. They may even have emotional significance. The situations in which they take place and the behavior that accompanies them at times suggest an analogy with a cry of alarm. When a youngster is separated from its mother, for example, much whistling ensues.

Think of the brain as an enormously complex electronic computer. Flowing into it is a continuous stream of neural impulses, initiated in the receptors and transmitted via the sen-

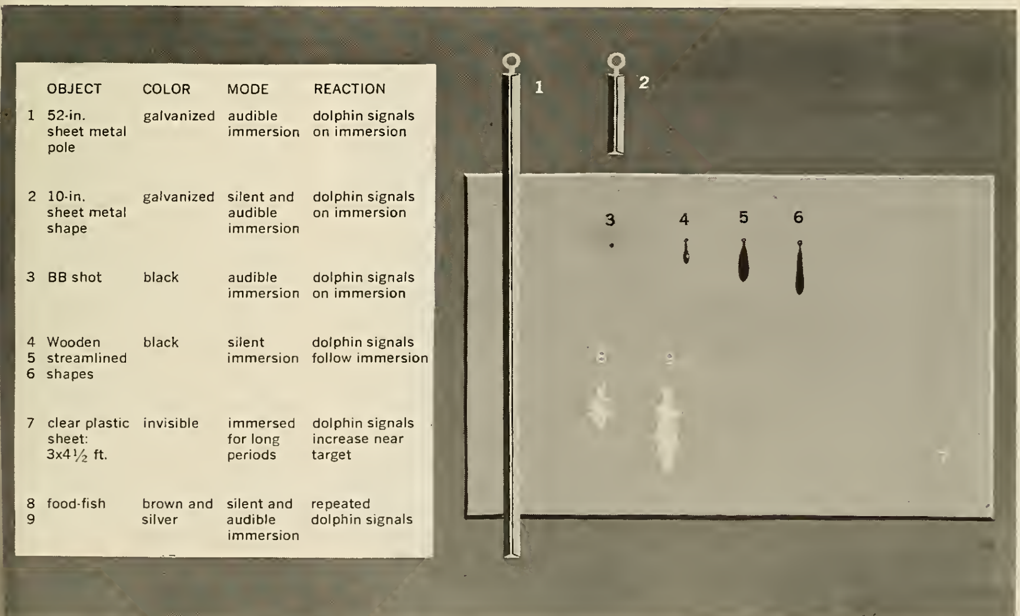
dolphin. Expanded series of dolphin clicks, *above*, shows original signals and returning echoes (the smaller spikes).

sory nerves. These impulses are decoded and sorted in the higher nerve centers. The process of classifying them and associating them with previously stored impulses is what is called perception. An ordinary man is unable to perceive very much about his surroundings merely by listening to trains of echoes reflected from objects nearby. But the structure of the bottlenose brain, the adaptation of its acoustic receptor, and its responsiveness to ultrasonic frequencies all point to a remarkable capacity in this direction. There can be no doubt that this dolphin species possesses a receiving mechanism that is quite sufficient to take care of its own echo-ranging signals. The next question is how to demonstrate the bottlenose dolphin's extraordinary perceptual ability of reacting to waterborne echoes.

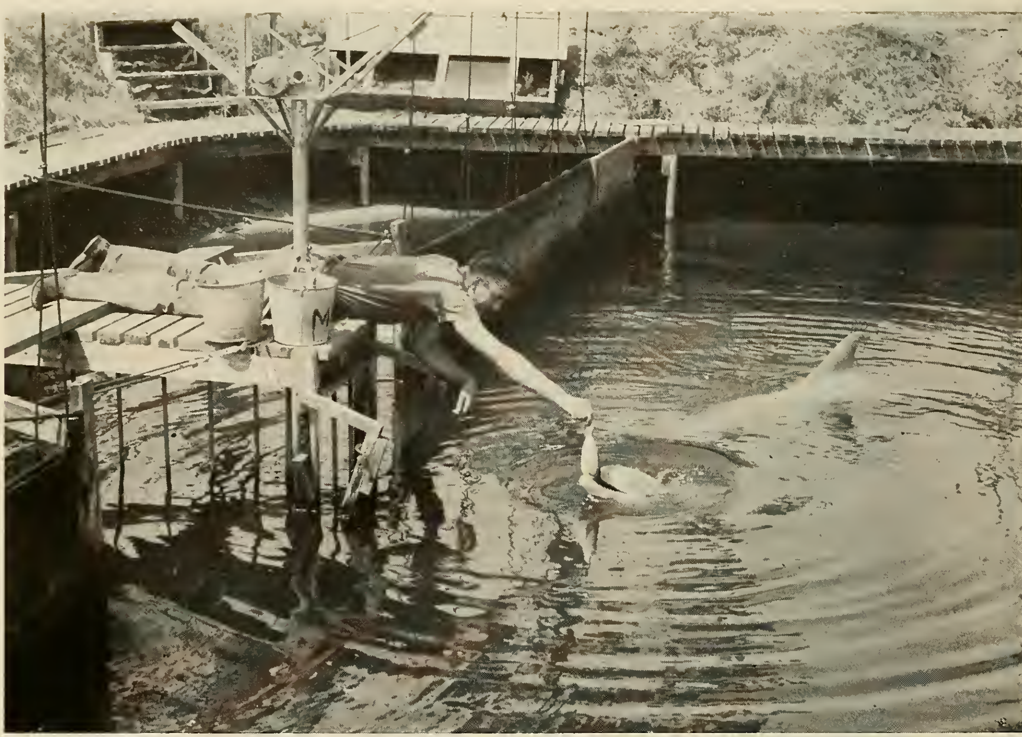
To investigate the question, we found it necessary to get dolphins under closer observation than had previously been possible. The way to discover more about their sonar, we argued, was not to study the wild animals at sea. Nor was it to make sporadic observations of animals in public aquariums. We had to have some specimens that we could study under controlled conditions. It would be almost impossible to transport such large, water-dwelling animals into a standard acoustics laboratory. But we could build a *special* laboratory, together with the proper equipment for working with the dolphins in their natural environment.

Our laboratory consisted of a large outdoor pool at the Marine Laboratories of Florida State University, forty-three miles south of Tallahassee at Alligator Harbor on the Gulf Coast. The mud and marl from which the pool was excavated gave soft, sound-absorbent sides and bottom, ideal for studies of echo-ranging, since they reflected few echoes.

The over-all dimensions of the enclosure were 70 by 55 feet, with a depth at low tide of five and a half feet



	OBJECT	COLOR	MODE	REACTION
1	52-in. sheet metal pole	galvanized	audible immersion	dolphin signals on immersion
2	10-in. sheet metal shape	galvanized	silent and audible immersion	dolphin signals on immersion
3	BB shot	black	audible immersion	dolphin signals on immersion
4 5 6	Wooden streamlined shapes	black	silent immersion	dolphin signals follow immersion
7	clear plastic sheet: 3x4½ ft.	invisible	immersed for long periods	dolphin signals increase near target
8 9	food-fish	brown and silver	silent and audible immersion	repeated dolphin signals



Prelude to experiment involved hand-feeding of the two dolphins, *above*, to accustom them to contact with handlers. **First fed on mullet, the captive pair soon began to refuse this fish, thus setting the stage for a discrimination test.**

and a depth at high tide of about seven feet. At the south end were two individual cells, or cages, 15 by 25 feet, which could be closed by doors projecting above and below the water line. Salt water was supplied through a sea wall, which protected the excavation from wave damage. A walk was built around the edge of the pool at the water line, and a small dock protruded from the south bank.

Along each of the longer sides of the pool were rows of small telephone poles. Cables were stretched horizontally between these poles, 10 to 15 feet above the water. From the cables we could lower plastic partitions, wire fencing, or underwater acoustical apparatus at any place in the pool. We could also haul observers out over the water in "bosun's" chairs.

Into these surroundings were placed two fine animals donated by the Marine Laboratories, of Marineland, Florida. With such facilities, we went to work in earnest. First to be investigated were the reactions that the porpoises made to submerged targets of different size and shape. To this end, we set up acoustical equipment and kept a hydrophone almost constantly in the pool. Some of the hydrophones, which were used in this work, (a Navy type 3A and three type AX-58's) were loaned on contracts with the Office of Naval Research. Additional sound apparatus consisted of a Navy type 1K transducer or underwater speaker, tape recorders of different sorts, oscilloscopes, oscilloscope camera, highpass and adjustable band-pass filters, air speakers, and other accessories. This equipment (exclusive of hydrophones) was housed in an apparatus room in a laboratory building that was adjacent to the dolphins' pool.

We listened to the underwater noises made by the animals as reflecting targets were submerged. The sounds were picked up by a hydrophone and were sent through an air speaker so that human observers could hear them. The sounds were also fed to tape recorders, for subsequent analysis in the laboratory. We could record frequencies to 100 kc. ±5 db.

The sounds were also transmitted to a cathode-ray oscilloscope and were either photographed directly or from a playback of the tape. In some instances, listening, recording, and photographing were undertaken simultaneously. In addition to the study of the sonar-clicking responses, the ability of the animals to locate, approach, and avoid submerged targets was tested. These targets varied in size, shape, and solidity.

The possibility that vision was used by the animals in any of the tests was eliminated by the turbidity or opacity of the water within the enclosure. Shoal water in Alligator Harbor is cloudy and brownish from about April through November (depending on water temperature), although it clears somewhat during the winter months. This natural turbidity was augmented in the pool by the mud stirred up by the animals' swimming.

Measurements of turbidity were taken regularly with a 20-centimeter Secchi disc, a circular, white, reflect-

ing surface, which is submerged in a vertical direction until it becomes invisible. The depth at which it disappears from view is measured in inches from the surface. For the purposes of this investigation, divers also made Secchi measurements in a horizontal direction within the pool, about one foot below the surface of the water. The horizontal thresholds obtained in this way were found to be about equal to the vertical readings. The transmission of light was further checked by transparency measurements of water samples with a photoelectric colorimeter. The results of these tests confirmed the Secchi readings.

During the months when our observations were made, the Secchi thresholds averaged 24.1 inches, with a standard deviation of 10.1 inches. Since the Secchi disc is a brilliant white, this means that black or neutral stimuli—like many of those used in these studies—would disappear from view at shorter distances. Nevertheless, to insure a more than adequate margin of safety, test objects were immersed in the present instance from eight to fifty feet from the nearest dolphin's position. These targets were put in only when the animals were at rest—that is, in one position in the pool. As a final control on the remote possibility that vision played any part whatever in the reactions of the animals to submerged objects, some tests took place at night during the dark phase of the moon.

The sonar-like clicking sound was the basic response made by the dolphins to the objects we immersed. Separate trains or bursts of these sound signals occurring in the pool would generally last from one to five seconds, although successive series might follow one another rapidly. The spacing, or rate-per-second, at which the individual pings took place within any given train or series varied considerably. This variation extended from only a few to as many as several hundred pulses per second.

The animals appeared to alter the spacing or timing of the pulses in accordance with what they were pinging or beaming on. Our observations suggest that the pulses occurred closer together if a dolphin swam toward a target after its immersion. In some cases, an animal would change the rate-per-second of the pulses within the limits of a single burst. If, for example, the clicks started slowly but accelerated in rate-per-second, they would be individually audible to human ears at first, but would lose their identity as the whole series took on a tonal quality of its own.

Perhaps the simplest method of eliciting the underwater sound clicks was to throw a pebble into the water. The noise of its splashing was followed immediately by one or more trains of pulses. Stronger splashes, such as those caused by a rock or pebbles, elicited louder and longer reactions.

Observations like these led to a systematic attempt to examine the effects on both the auditory response and the general behavior of the animals that might be produced by different sorts of sound-reflecting targets. We made streamlined objects that could be lowered slowly into the water at the end of a line without causing the slightest noise on immersion. Other targets were prepared that were intended to produce water noise or surface splashing. Whether or not any sound occurred on contact with the water was continuously monitored by underwater listening.

The shape and over-all dimensions of nine of these devices are shown on p. 33. Items 1 and 2 in this figure were made of 28-gauge sheet metal and were triangular in cross section, two inches to the side. Item 3 represents a BB shot; items 4, 5, and 6 are black, streamlined shapes; item 7 is a clear plastic sheet; and items 8 and 9 represent food-fish, chosen approximately in the lengths indicated. The last two targets may be considered "soft" targets, in the sense that they absorb auditory vibrations better than the others. No change was noted in the character of the sonar response in such cases, although it may be assumed that the echoes these targets returned would be different in frequency composition from those sent back by harder reflecting surfaces.

To discover the effect of splashing, alone, on the animals, isolated splashing sounds were produced without the subsequent insertion of a target. The best method of accomplishing this was to drop measured quantities of water from known heights above the surface. This was done by an assistant suspended over the center of the pool in a "bosun's" chair. Tests were made in calm weather when there was no wind or water disturbance.

We found that the noise made by a single drop of water from a height of approximately five feet was a below-threshold stimulus. But a half-teaspoonful of water, or larger amounts, would invariably elicit the

Small spot, the preferred fish, and larger mullet were both offered to the hungry dolphin. A plywood screen kept the experimenters' moves out of sight.

sonar response. Water from a half-inch garden hose—played even momentarily upon the surface—produced great disturbance, loud sound signals, undulating "alarm" whistles, and "fright" swimming reactions.

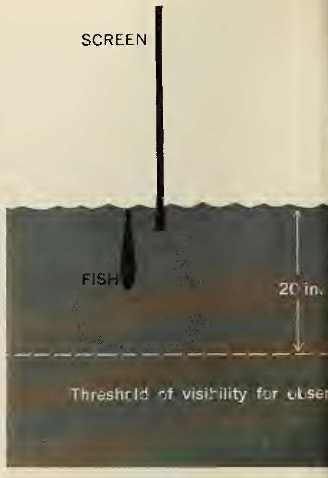
On several occasions, a sudden shower of rain would fall while we were experimenting. The animals' responses were the same as to the jet from the hose—presumably because the relatively shallow depth of the pool allowed no escape from the surface din to deeper and quieter water.

It became clear from these observations that clicking noises could be triggered by splashes of almost any kind. But such responses were not sustained unless reflecting targets—from which echoes would return—were actually present after the splash. The "plunk" made by a single BB shot, for example, was sufficient to initiate a train of signals. Since the shot sank rapidly, however, the sounds soon stopped.

Some special results came to light during these tests. First, even though they remained in the same location within the pool, the animals emitted periodic trains of sound pulses every 15 or 20 seconds. These appeared to be exploratory pings, equivalent to "glancing" or "peering" in the field of vision. Second, a food-fish silently immersed from in back of a screen elicited no reaction until a train of exploratory beaming signals indicated its presence. Thereupon, the trains of echo-ranging noises became almost continuous as the dolphin approached and took the bait. Since an animal usually lay at or near the top of the water during feeding, it could clearly be seen to lurch or jerk forward by giving a powerful movement of its tail flukes the moment echoes were received. It obviously "knew" that a food-fish had entered the tank, even though visual perception was impossible in the turbid water.

In swimming toward a small target, such as food-fish held beneath the water, a dolphin could often be seen to turn its head alternately to the right and left. Oscillating head movements occurred only (a) while the animal was emitting trains of sound pulses and (b) when the target toward which it was swimming could not be visually identified because of the turbidity of the water. Observations of this phenomenon indicate that a complete cycle takes place in from two to three seconds. The oscillating activity was noted up to ten feet from the target, and it continued until the dolphin came close enough to seize the food.

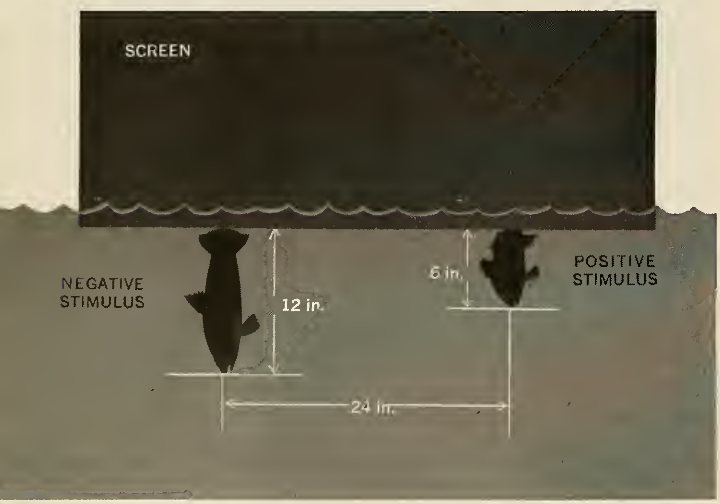
The only adequate interpretation of this activity appears to be that it is a means of orientation to the echoes of the sound signals that are reflected back from the target. The sound pulses broadcast by the dolphin do not appear to be highly directional—probably no more so than the human voice.



But the echoes returning from an object at a fixed point would vary continuously as the locus of the animal's ears changed with reference to the source of the echoes.

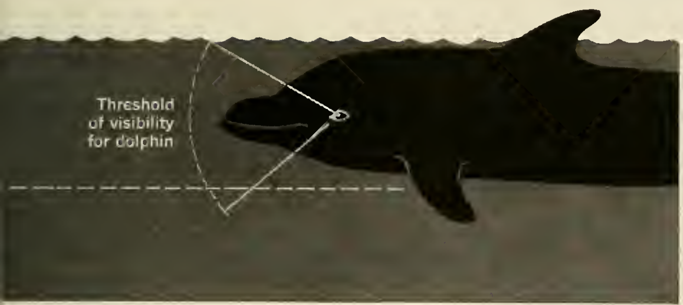
The oscillation of the head is exactly what one would expect in the pinpointing of an object by means of reflected sound. It is the same sort of activity in which a human being would engage if he were using binaural localization. The head movements of the animal would constantly modulate the phase and intensity differences of the echoing sound waves reaching each of the ears. They would also alter the time interval between the emission of a pulse signal and the return of its echo to each ear. The continuation of the process as the dolphin swam forward would enable it to determine with great precision the direction from which the echoes came.

Since the noises that make up the echoes are emitted by the animal itself, the activity as a whole amounts to a kind of scanning by sound. We suggest, therefore, the term "auditory scanning" as a good name for both the acoustic and the general behavior comprising this elaborate pattern of activity. The stream of information produced by auditory scanning must be instantly analyzed by the animal's brain. The mechanical counterpart of such a receptor system would be a sonar apparatus with one transmitter and two independent receivers, plus an electronic computer capable of decoding and processing the data—all within a single compact unit.



Discrimination test, diagramed here, faced dolphin with choice between the two fishes at distances where visual basis for the selection was ruled out.

Approaching bait, the dolphin, *below*, could not make use of vision, because of the turbidity of water in the pool.



Even though dolphins evidently possess a fine sonar system, it still remains to be demonstrated that the system is actually used for orientation and navigation. Do the animals employ it in a positive way to seek and find food-objects? Do they employ it in a negative way to avoid obstacles while swimming?

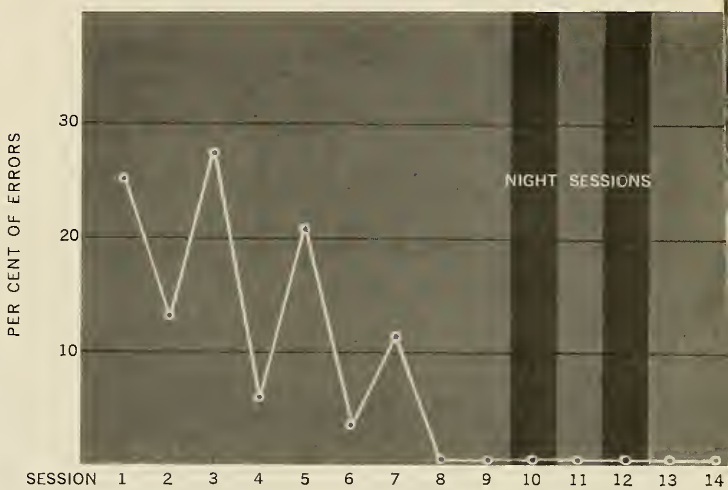
At the laboratory in Alligator Bay each dolphin was fed daily from 15 to 18 pounds of fresh (frozen, but defrosted) fish. The fish were either thrown into the pool one at a time or fed to the animals directly from the hand. Suppose that a food-fish is thrown into the turbid water in such a way as to strike the water 30 feet or so from the two experimental animals. If the test is to be critical, the animals should neither be able to see the fish in the air nor should they be able to see the motions of the thrower. The instant the bait strikes the water, both porpoises immediately turn and race toward it at maximum speed, although, before they can arrive at the spot, the fish will have sunk.

By then, the bait is not visible to human observers on the bank, nor to the animals. Yet one or the other of them never fails to retrieve it and usually surfaces almost immediately with the fish in its mouth. The whole procedure takes but a few seconds. There is no exploratory or searching behavior whatever. It is clear, of course, that the sound of the splash gives the direction for swimming. But the sonar process is undoubtedly used in finding the fish as it sinks.

Can senses other than hearing be used for locating such a submerged target? Obviously, the method of discovery in extremely turbid water cannot be a visual one. It cannot be olfactory, for the sense of smell is missing in these animals. Gustatory reception seems highly improbable in such a situation, for the chase and seizure of the fish are much too fast for any tasting to take place. There remain the tactual and temperature senses, and hearing. We are forced by the process of elimination to infer again that hearing is the sensory channel employed.

At first, our two subjects were fed on mullet, but they soon began to refuse this fish. It therefore became necessary to supply them with a fish called spot, which they ate readily. Either of these food-fishes, held by the tail beneath the surface of the water, would be approached from distances well beyond the range of visibility. Upon contact with a mullet, a dolphin would reject it: the spot would be seized and eaten. A similar distinction existed when the fishes were thrown into the water at a point distant from the animal's position. Both spot and mullet would be actively chased, but the mullet was almost never taken by the dolphins.

As a consequence of this behavior, the question arose whether the animals could discriminate between a preferred fish (the spot) and a non-preferred fish (the mullet) without seeing either fish. The sonar process would then have to be used as the method of selection. With the use of this natural preference, an experiment was arranged to which proper controls could be applied. The discriminating cues were differences in the sizes of the preferred and non-preferred stimuli. To this end, mullet, which were about twice as large in over-all length as the spot, were selected. The subject of the experiment was Albert, a young and vigorous adolescent. Albert was over seven feet long and weighed in the neighborhood of 300 pounds.



Number of times that Albert touched or took the wrong fish soon diminished.

Sessions 10 and 12, on two moonless nights, proved vision of no importance.

Dr. Kellogg, who is Professor of Experimental Psychology at Florida State University, has recently done a book — *Porpoises and Sonar* — (© 1961, University of Chicago) from which his article here is excerpted.

Two feet from the end of the enclosure's dock, which protruded 15 feet into the water at the south end of the pool, we placed a rectangular sheet of plywood, 24 by 28 inches. The plywood was fastened on brackets, so that it could be raised or lowered with changes in tidal level. During an experimental session, its lower edge was one to two inches beneath the surface. This left a vertical screen from behind which the target-fishes could be submerged without giving visual cues.

At the beginning of a trial, a man on the dock simultaneously lowered a positive and a negative stimulus (a spot and a mullet) into the water. A fish was held by the tail in each hand, so that both the tail and the hand were concealed behind the lower edge of the plywood screen. The points of insertion were two feet apart and were fixed with reference to the vertical edges of the screen. The distance of immersion was about six inches for the spot and about a foot for the mullet, measured from the bottom edge of the plywood. The positions of the positive and negative stimuli were randomly rotated from trial to trial.

This plan presented Albert with a size-discrimination problem. The positive stimulus (the spot) offered a smaller reflecting surface than the negative stimulus (the mullet). It was Albert's task to approach and take the spot and at the same time to avoid the mullet—without employing vision in the selective process. Albert was about 23 hours hungry at the start of any experimental session.

A trial began when the subject was completely "ready." Being ready consisted of the animal's coming to the top of the water and maintaining a fixed position several feet in front of the plywood screen. In such cases, the dolphin stopped swimming and lay upon the surface, waiting or "treading water." Its dorsal fin remained above the water, and the top of its head would alternately rise and fall a few inches every few seconds as it came up to blow. The man on the dock immersed the two fishes at the instant Albert was in the process of blowing. The fish were inserted head downward and silently. Any uncontrolled water noise, which may have occurred inadvertently, was adequately masked by the "whoosh" of the animal's blowing.

At the moment of immersion the fish-holder quietly said, "In." Upon this signal, the man controlling the instruments began to time the trial. Two independent time measurements were recorded, each of which began at the start of the trial. When Albert touched a fish with nose or mouth, the fish-holder said, "Contact." When Albert took the bait from his hand, he said, "Take." The fish-holder could tell by touch—both in daylight and in the night sessions—the instant Albert touched or took either fish.

Fourteen experimental sessions of this sort were conducted. These sessions were distributed irregularly—because of weather and other conditions—over a period of about six weeks. From fourteen to twenty-seven discrimination trials were given at a session, the exact number depending on the strength of the dolphin's hunger drive. When Albert refused to approach the feeding station, a session was necessarily terminated.

The percentage of incorrect choices, or errors, made by Albert in the 271 trials of this experiment have been plotted for each session. Errors represent trials in which the negative fish (or mullet) was either touched or taken. It is apparent from this curve (p. 37) that some learning took place, although the largest percentage of errors in any one session was no more than 28 per cent. This relatively low-error score indicates the degree of discrimination that was present from the very beginning—even in the artificial and unnatural situation of the experiment. In the last seven sessions (Numbers 8 through 14), totaling 140 trials, there occurred not one wrong choice.

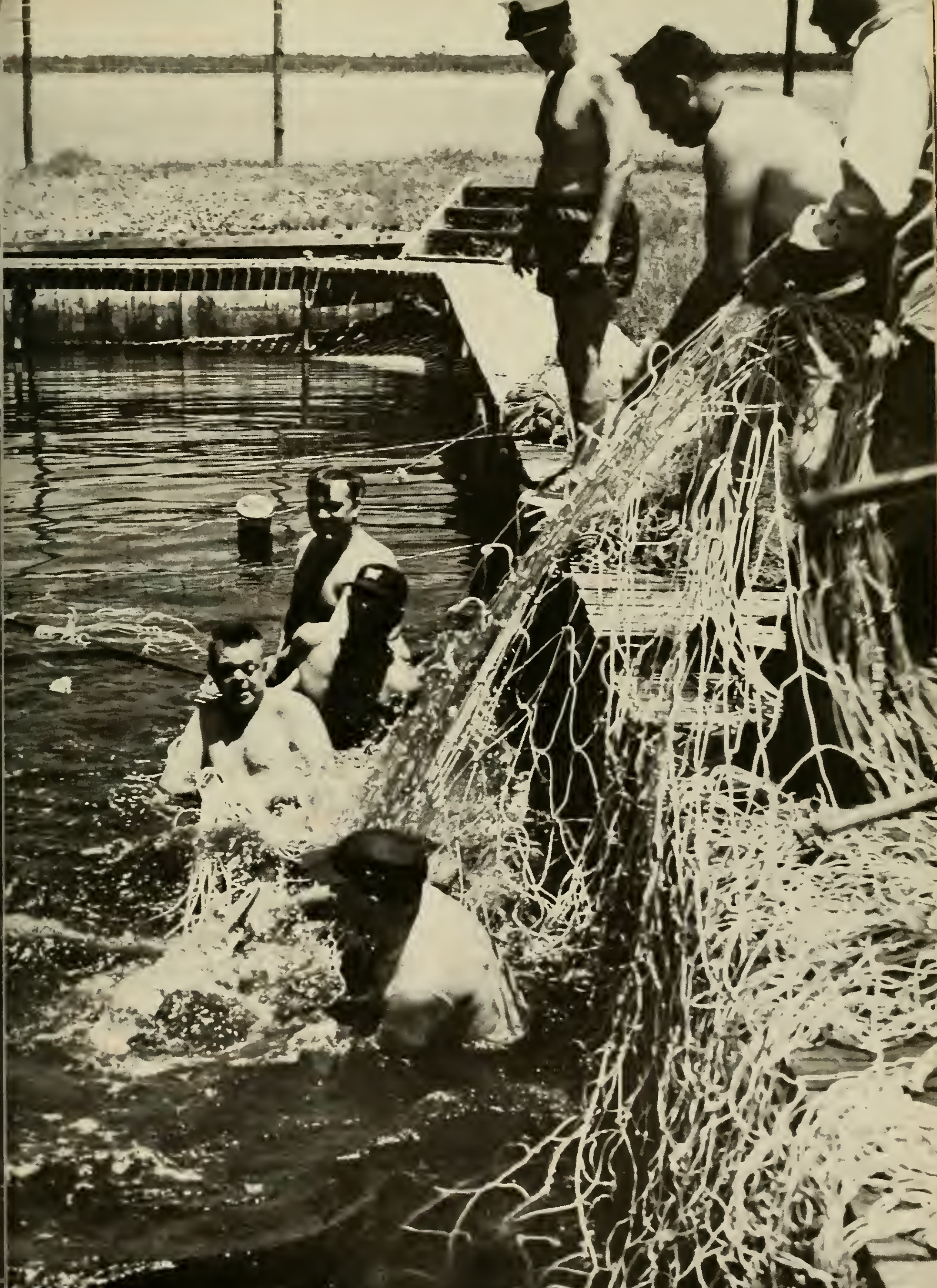
That Albert's discrimination was really accomplished by echo-ranging and not through some unknown sensory means was confirmed in three distinct ways. The first of these was the altered pattern of ping that occurred after the immersion of the target fishes. Underwater acoustical gear permitted observers to listen to the audible component of the animal's noises as the sounds were being produced on any given trial. Typically, Albert sent out intermittent bursts or trains of sonar pulses while waiting at the ready or starting point. The first series of signals, which occurred after the immersion of the stimuli—that is, the first series that would return echoes from the fishes—was accompanied by a forward lunge as the dolphin suddenly moved his powerful tail flukes. A start toward the goal was never made during a silent period between trains of signals. As Albert approached and took the bait, the pinging sound-trains became continuous, or nearly continuous. Moreover, Albert would sometimes oscillate his head to the right and left in approaching a fish, as dolphins are known to do in pinpointing a target.

Session 10 and Session 12 were conducted on nights when there was no moon. It was a fortunate coincidence that, on both occasions, the sky was also heavily overcast so that starlight was also eliminated. Albert's discriminating ability under these night conditions was quite the same as in the daylight. Lack of light did not disturb efficiency of performance, nor did it alter the dolphin's behavior in any observable manner. Visual perception in the turbid water of the pool would most certainly have been reduced—if not eliminated completely—in such darkness. Echolocation or auditory perception, on the other hand, would remain unchanged.

Finally, two supplementary control sessions were given in daylight at the end of the experiment. In these new trials, a six-inch spot was paired with a mullet that was now held, like the spot, so as to protrude *only six inches below the plywood screen.* The two stimuli, in other words, were in this case of approximately the same size. In the first control session, Albert made two errors. In the second session (20 trials), there were 10 errors. Combining the results of these two sessions gives a total of 40 per cent errors for the 30 control trials. Yet, in well over 100 previous trials—when the positive and negative stimuli had *differed* in size—the animal had committed no errors at all. Thus, elimination of size differential had obviously disrupted Albert's discrimination.

These facts seem to demonstrate conclusively both that Albert's discrimination was made on the basis of size and that it was made by means of the dolphin's echo-ranging capability.

Experiments ended, the two dolphins were removed from the laboratory pool and turned free in the Gulf of Mexico.



A startled flock of pelicans, which had been quietly feeding in the shallows of the lake, noisily take wing.

The Death of an Israeli Lake

ONCE A FISHERMAN ON LAKE HULE, in Israel. Peter Merom became enthralled with the changing aspects and moods of the lake in all its seasons—with its plants, its birds, its fishes, and with all the rest of its living things.

Now the lake is no more. Its 20 million cubic meters of water, which had been contained in about 3,500 acres, have been diverted into the Jordan River, and the area it once covered has been reclaimed into fertile fields. Today, what had been a lake is under intense cultivation, producing maize, rice, sugar cane, cotton, and other vital produce, as well as industrial crops. In addition, millions of gallons of water, formerly lost each year through evaporation from large lake-edge swamps, are now being used productively.

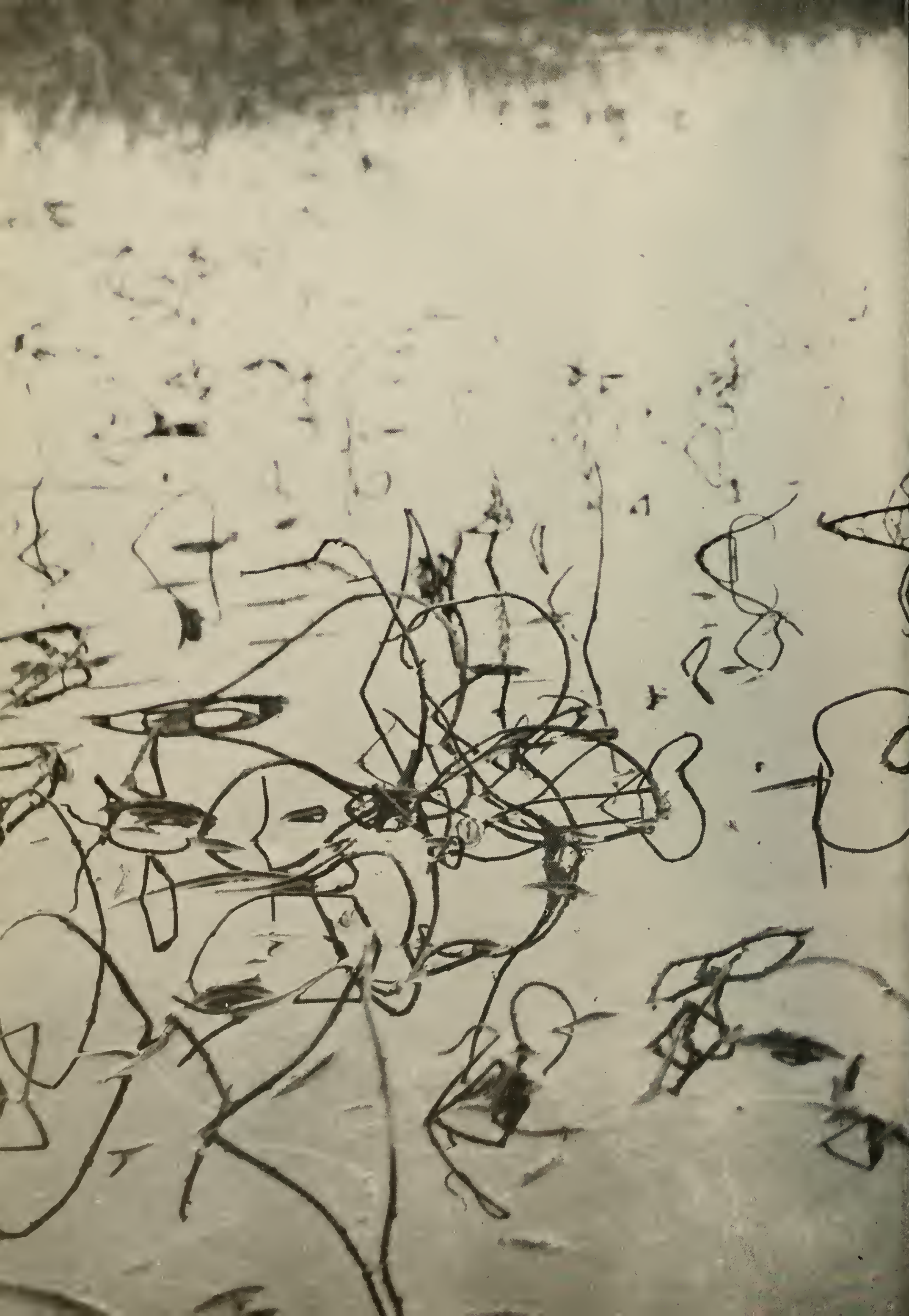
Just before the lake vanished, Peter Merom began to use a camera. Then photography, which began as a hobby, became a livelihood, and his work has been published in eight books, including *The Death of the Lake*, from which the pictures on these pages have been reproduced. They chronicle one man's subjective view of a loved and well-known region, from its lush days of flocks of birds, myriad plants, and abundant fishes, to the first weeks after the lake died.

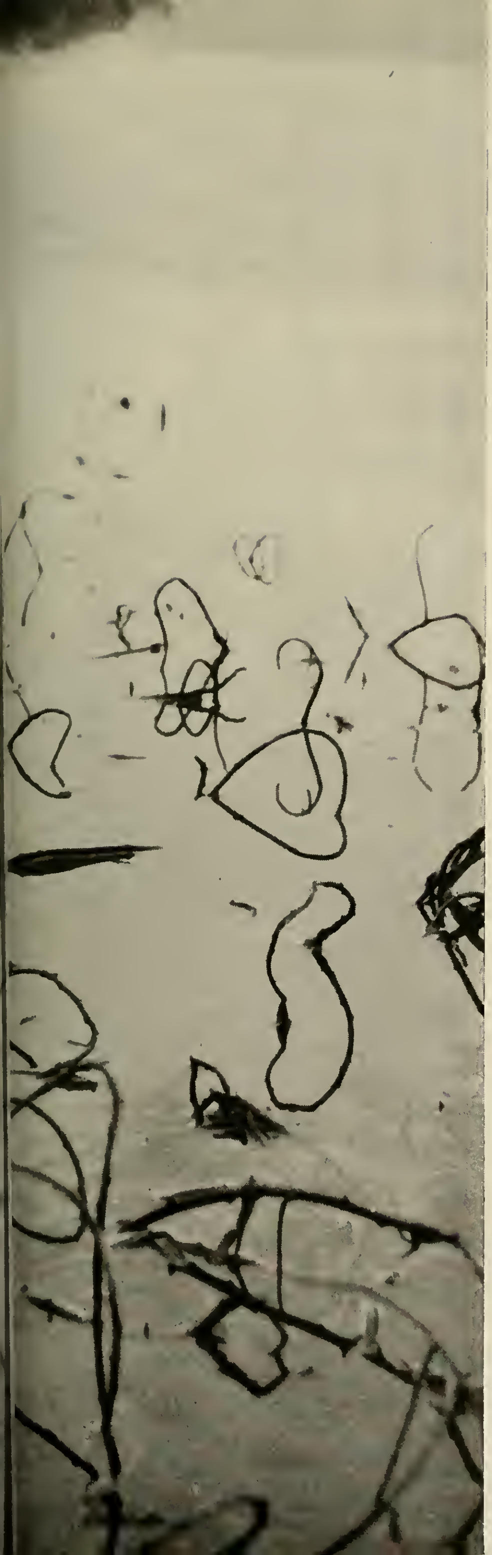
While Lake Hule's replacement by much-needed agricultural land is of benefit to the country of Israel, the naturalist in Merom could not avoid a few pangs of regret. That regret is clearly mirrored in his sensitive recording of what had for many years been his familiar fishing grounds.

Great crested grebe, undisturbed, swims low in the water, its distinguishing head feathers flattened and generally inconspicuous.

With flaring crest and spreading feathers forming skirtlike frills at its neck, aroused grebe is ready either to attack or defend.

Water plants stand in the shallows of Lake Hule, washed by the gentle ripples from passing boats or, perhaps, of a passing breeze.

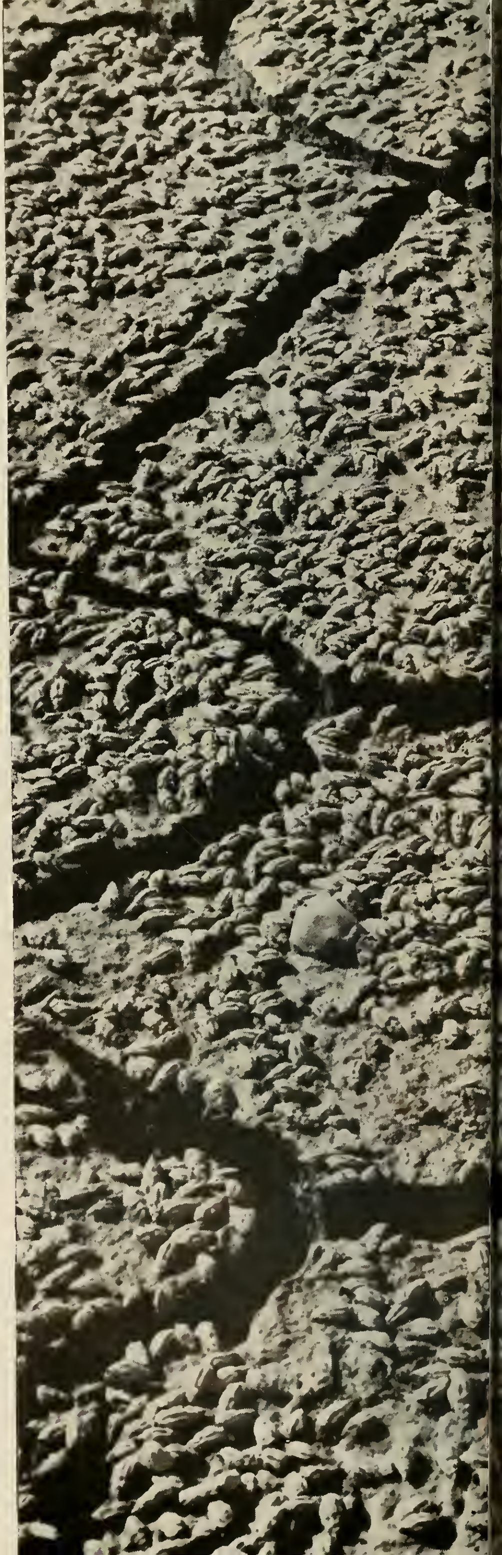




As the waters slowly recede, alternatives for many lake creatures are removal from the area or death.

The water plants no longer stand erect. Instead, their jointed stems bend and break while the lake withers.

Before the water left, little snails could be
found clinging to the smooth, bright green leaves of plants
that grew abundantly in the swamp and in the shallows.



The lake has vanished. On the desiccated earth,
now fissured as if by an earthquake, are scattered tiny, mute
remnants of water life—thousands of empty snail shells.

In the Quiet

The camera captures the odd

Photographs by

WATCHING INSECTS WHIR ABOUT, one might conclude that the creatures spend their lives in ceaseless activity. This conclusion, according to Dr. Fritz Schremmer, would be fallacious. An entomologist with the University of Vienna's Zoological Institute, Dr. Schremmer discovered that many insects really pass much of their lives in sleep.

Sleep: the word evokes thoughts of a comfortable bed or a soft chair, for human beings normally sleep in a prone or reclining position. However, as Dr. Schremmer's photographs show, insects take their rest in a variety of positions, most of which look not the least bit restful.

Many solitary bees and some types of wasps, for example, assume bizarre postures during slumber. Upon retiring, they climb a plant's dry stem or proceed to the tip

Mason wasp winds its body closely around stem of a plant.

Another bee fly, Bombylius major, hangs from twig's bottom.

Proboscis of the Bombylius punctatus bee fly points to sky.

of the Night

postures of sleeping insects

FRITZ SCHREMMER

of a blade of grass, gripping the perch firmly with their mandibles. This grip may be so secure that the insect will draw its legs up close to the body, since they are not needed for support. Sleep itself may bring on a sort of cataleptic rigidity. Certain bees may be able to remain thus suspended by the jaws for several hours or even for days.

Another strange sleeper is the mason wasp, *Celonites abbreviatus*, which grips the stem of a plant with its legs and, often, with its jaws, then rolls its body around the stem. Equally odd is the tendency of the male burrowing bee, *Halictus calceatus*, to gather in groups of up to forty, clustering on the empty fruiting bodies of various plants. They crawl about and clean themselves before falling asleep, then rest quietly en masse until awakened by daylight.

Nomada flavopicta parasitic bee grips grass blade in its jaws.

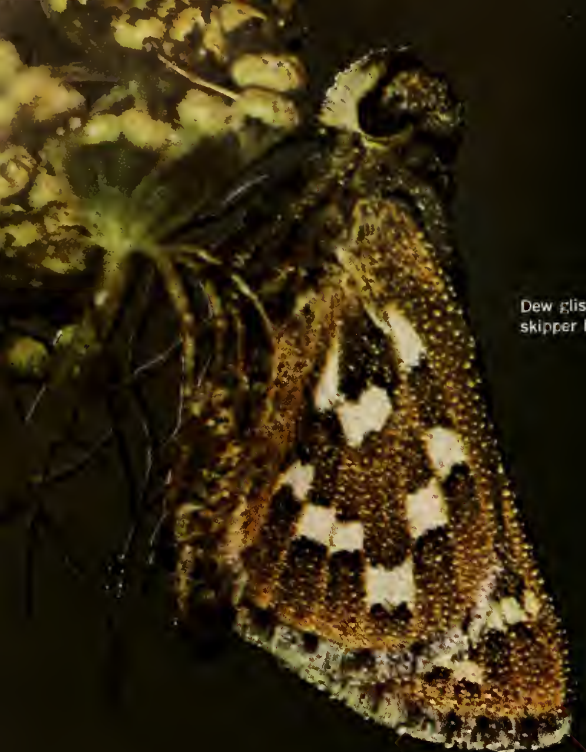
Burrowing bee group rests on fruiting bodies of a teasel.

Blue butterfly of family
Lycaenidae slumbers head down.

Legs support a sand wasp's
body as mandibles clamp a stem.

Digger wasp Cerceris rybensis
sleeps in seed capsule of catchfly.

Bee Trachusa byssina hangs
by its mandibles from tip of leaf.



Dew glistens on wings of skipper butterfly as it rests.

A male bee of leafcutter family uses jaws to grasp stem.

Gymnosoma rotundatum, a parasitic fly, sleeps on teasel.

SKY REPORTER

he constellations known as the Royal Family are rich in interest

By Simone Daro Gossner

HE RELATIONSHIP between astronomical lore and ancient mythology is most apparent in the grouping the constellations Cassiopeia, Cepheus, Andromeda, and rseus. Often called the Royal Family, these heroic figures the protagonists of one of the most ancient legends of nkind. The Greek myth from which these names are en is well known: Cassiopeia, wife of the Ethiopian King pheus, offended the Nereids by vaunting the superior uty of her daughter Andromeda. Thus, she aroused the ath of Poseidon, God of the Sea, who sent the monster Cetus to ravage Cepheus' land. To appease the monster, the oracles said, Cepheus should chain Andromeda to a rock and let her be devoured. And chained she was—with unpaternal alacrity. Her plight drew the attention of Perseus, son of Zeus and Danae, as he passed the fateful rock on his return from slaying the Gorgon Medusa. Perseus killed Cetus and, soon after, he claimed Andromeda as his bride.

This Greek myth, however, is only a relatively modern and somewhat altered version of a much older story. It is found in Babylonian and Hebrew mythology, and appears

to derive from a yet earlier Sumerian legend. But in all except the Greek version, the woman chained to the rock is the villain of the story, rather than its potential victim. She is the treacherous goddess Ishtar (Astarte) of the Babylonians, who was chained to the rock by Perseus—known as Marduk in this version of the story—because she herself had called forth the sea monster.

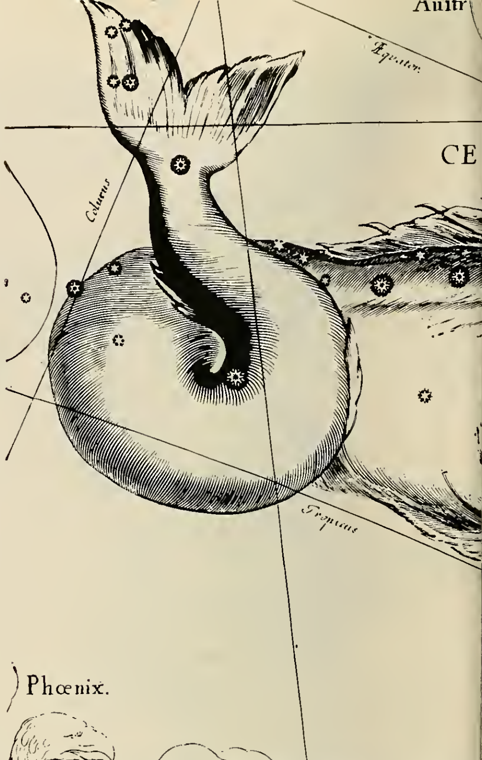
Although the Sumerian story has not yet been pieced together from the fragmentary passages already deciphered, all its elements seem to be present. There can be little doubt that these mythological figures first took shape in the minds of men more than 5,000 years ago. Whether they were associated with sky constellations at such an early date, one cannot say. But the great antiquity of the stories may throw some light on the puzzling attribution of Eridanus, one of the constellations near Cetus.

Eridanus is a great river—some say an ocean—and, from its placement on the celestial sphere, it appears as the body of water from which Cetus sprang. But there is remarkably little agreement among ancient authors concerning the terrestrial river that it symbolizes. To Ovid, it is merely the mythical river that engulfed Phaeton's sun chariot when it fell from its appointed course. Hyginus, on the contrary, specifies that it is the Nile, whereas Caesar Germanicus' Commentary on Aratus identifies it with the river Po. Yet the most important river in Sumerian legends was the Euphrates. If one adds to this the fact that the principal Sumerian city at the mouth of the Euphrates was called Eridu, one might well wonder whether Eridanus was originally the celestial symbol of that great river (although one would simultaneously have to assume an oral tradition that allowed the name to survive at a time when the Sumerian language had been forgotten for centuries).

Astronomically, the region of the sky encompassed by the constellations of the Royal Family and their immediate neighbors contains a number of interesting telescopic objects, as well as several stars of historical importance.

At the beginning of November, 1572, one star in Cas-

Great nebula in Andromeda, actually an entire galaxy, is located among flowing tresses below figure's right elbow.



Omicron ceti, known also as "the wonderful," is a famo variable star, visible to the naked eye only for some s

siopeia suddenly flared with the extraordinary brillian of a supernova. Within a few days, it had been noted a observed by several astronomers. As is often the case wi bright ephemeral objects, it is difficult to say who was t first to see it. In the light of recent evidence uncovered C. D. Hellman, it would seem that Maurolyco's observ tion was probably the earliest of which a record was ma However, *Nova Cassiopeiae 1572* owes its fame to the tensive observations of Tycho Brahe, who followed it siduously until it finally faded out of sight in March of 15 Very little now remains visible of "Tycho's new sta which must have spent itself in the cataclysm. Only a w of nebulosity is seen in large telescopes. The strong ra emission from that region of the sky, however, is alm certainly associated with the same object.

Delta Cephei—the star in Cepheus farthest away fr the North Pole—is the variable star for which "Cephei are named. With noteworthy regularity, its brightn varies over a magnitude range of 0.7 in a period of 5 days. A rapid rise to maximum (in about 1.5 days) is lowed by a somewhat wavering decline over the remain four days. No satisfactory explanation has been given yet for the cause of this variability; the current belie that it arises from a pulsation in the star's atmosph Several hundred variable stars of this type have since b discovered, including some in a few nearby galaxies. T periods vary, but they exhibit a truly remarkable prope the length of the period is directly proportional to the trinsic brightness—or absolute magnitude—of the Ceph Thus, if the period is measured, the absolute magnit

›nths of its year-long cycle. In this drawing, it is the ·ger star central to the legendary beast's plumed neck.

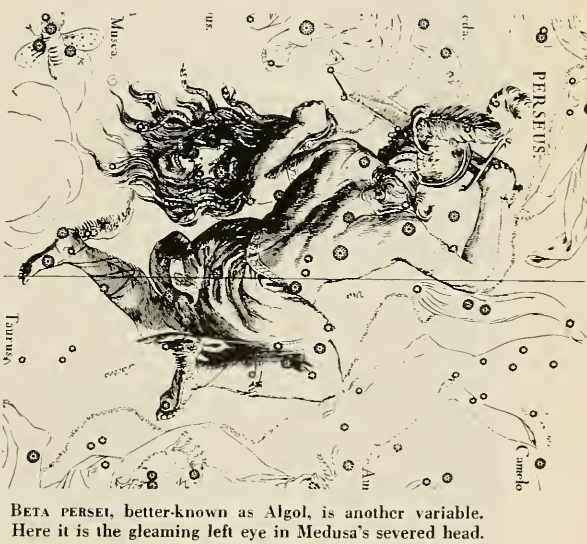
ıy be derived. The latter, in turn, may be compared with ː apparent magnitude to obtain the distance of the star, the same manner that the distance of a lightbulb of own candle power may be estimated from its apparent ightness. This procedure has provided researchers with e of the classical yardsticks of astronomy.

LSO well-known prototypes of other kinds of variable stars are Beta Persei and Omicron Ceti. Beta Persei, :ter-known as Algol (see NATURAL HISTORY, August-ptember, 1960). is a typical eclipsing variable. In other ›rds, the changes in its brightness do not arise in the r itself, but they are caused by the mutual eclipses of ɔ stars so close to each other that they appear as one in ː telescope. First detected by Montanari in 1670, the riability of Algol was correctly explained for the first ıe in 1783 by the young Englishman John Goodricke, o, incidentally, had also discovered the variability of lta Cephei. Modern studies have since disclosed that ʒol's dual system also includes a third star, which re-ves around the other two in a bit less than two years. Omicron Ceti was named Mira, "the wonderful." be-ıse of its most peculiar behavior. It is classified as a g-period variable, with a period of the order of one ır. In fact, the period itself varies by a few weeks from ː cycle to the next. What makes it truly remarkable is t Mira has one of the widest magnitude ranges in that egory. For five or six months, it is visible to the naked ː as a star of intermediate brightness, although it may asionally rise to the second magnitude. Then it gradually fades out of sight until, for the rest of its period, it is observable only with a telescope, its minimum magnitude ranging from $+8.5$ to $+9.6$. "The wonderful" then gains brightness and reappears six months later.

Telescopic objects abound in the region of the Royal Family, although a detailed sky map may be required to locate them (we like Norton's *Star Atlas*). Cassiopeia is a rewarding hunting ground for double and multiple stars: Psi and Eta are easily resolved in a small telescope; Iota appears triple in a four-inch instrument. Also in Cassiopeia may be found two of the many star clusters catalogued by Charles Messier (1730-1817): M52 and M103. The second of these is not a cluster in the modern sense of the term—that is, it is not a close physical association of stars—but is rather a rich star field within the Milky Way's belt.

The most conspicuous feature in Perseus is the famous Double Cluster, known to the professionals as "h-and-chi." It is visible to the naked eye and shows up handsomely even in a pair of binoculars. Its easternmost component contains a deep-red star. Like Cassiopeia, Perseus lies in the Milky Way and we shall visit it again in this series.

THIS roundup would not be complete without a mention of the Great Nebula in Andromeda, even though we shall study it later in greater detail. To the unaided eye, the Great Nebula appears only as a faint, hazy patch. Shortly after the telescope was first used in astronomy (1610), the richness of star fields in the Milky Way became apparent. In spite of the fact that the early instruments could not detect individual stars in the Andromeda Nebula, it was surmised by some astronomers that this object, too, might be an aggregate of stars. Nearly three centuries elapsed before this assumption was confirmed and it was shown that the Great Nebula was not only a stellar aggregate, but also a vast system of stars totally removed from our own Milky Way and a galaxy in its own right. Its spiral structure is revealed by the larger instruments. When it is viewed through a small telescope, the Great Nebula appears as an elongated oval with a bright nucleus.



BETA PERSEI, better-known as Algol, is another variable. Here it is the gleaming left eye in Medusa's severed head.

THE SKY IN FEBRUARY

From the Almanac:

New Moon	February 4, 7:10 P.M., EST
First Quarter	February 11, 10:43 A.M., EST
Full Moon	February 19, 8:18 A.M., EST
Last Quarter	February 27, 10:50 A.M., EST

For the visual observer:

As in preceding weeks, planets will remain poorly placed for observation, because of their proximity to the sun.

Mercury, at inferior conjunction on February 5, will enter the morning sky on that date. It will rise forty-five minutes before the sun on February 15, and one hour and fifteen minutes before the sun on February 28. It might be found low in the southeast, at dawn, in the latter part of the month. It will brighten perceptibly from +1.1 magnitude on February 15 to +0.4 on February 28.

Venus, in the evening sky (−3.4 magnitude), will be too near the sun for observation. Its apparent distance from the sun will increase somewhat toward the end of the month, but even on February 28 it will set only about 40 minutes after sunset, low in the southwest at dusk.

Jupiter, in Capricornus (−1.5 magnitude), will be at conjunction on February 8, entering the morning sky on that date. Hence, the planet will be lost in the sun's glare throughout the month. By February 28, it will rise in the southeast approximately half an hour before the sun.

Saturn, also in Capricornus (+0.9 magnitude), will be too close to the sun to see at the start of the month. However, it will gradually pull away and will rise one hour before the sun on February 15, and one and a half hours before the sun on February 28. Except for the first few days of February, it should be found easily in the morning sky, low on the southeast horizon.

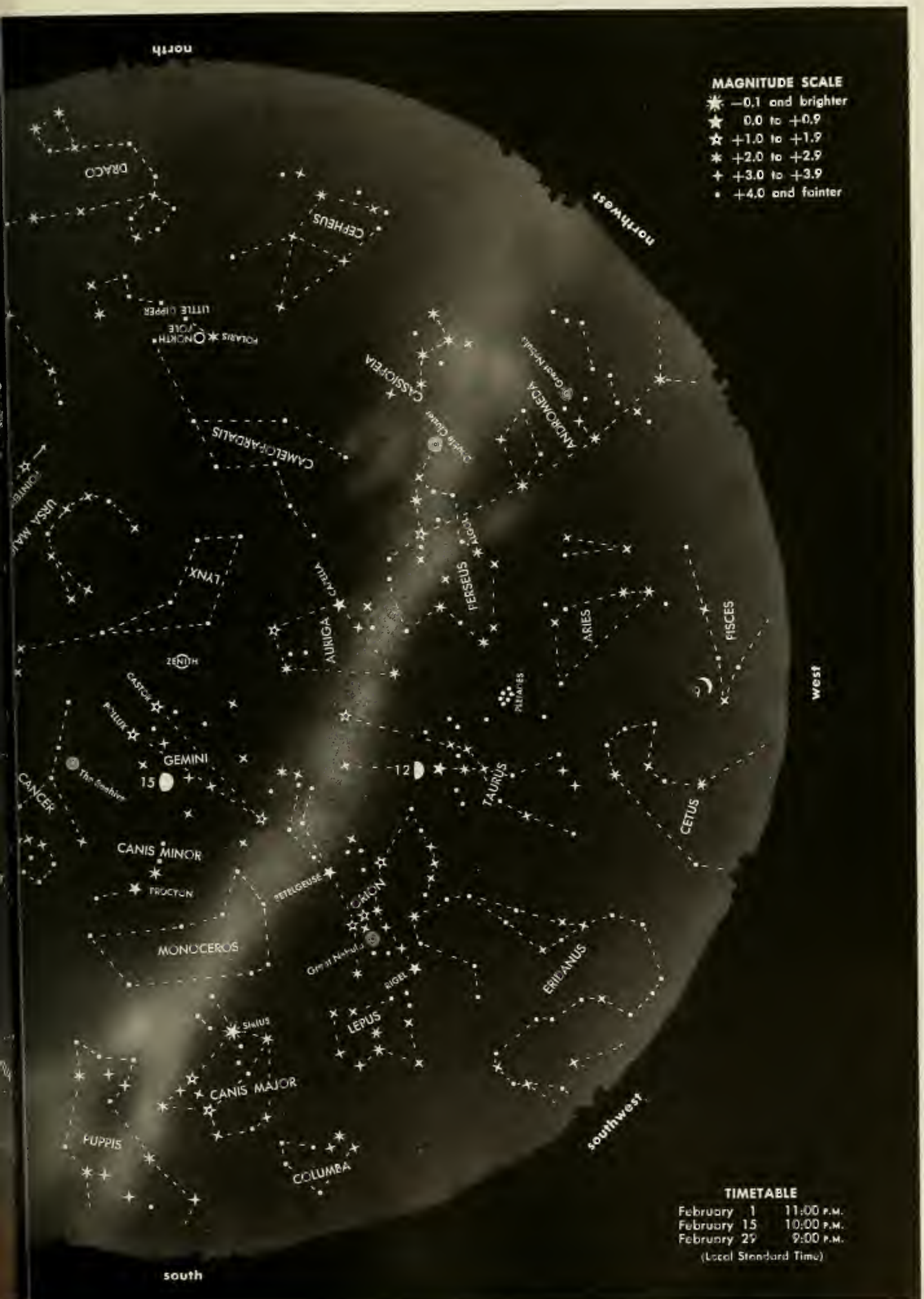
Eclipses:

A total eclipse of the sun will occur over the Pacific Ocean on February 4/5 (Greenwich Time). The track of the total phase will begin at sunrise on the island of Borneo, and will end at sunset about 600 miles west of the south tip of Lower California. It will be seen as a large partial eclipse in Hawaii. Western sections of California, Oregon, and Washington will be the only parts of mainland states to get a glimpse of the phenomenon (as a partial eclipse).

A penumbral eclipse of the moon will take place on February 19. The beginning will be seen—weather permitting—throughout the United States, but only Alaska and Hawaii will see the entire event; elsewhere, the moon will set while the eclipse is still in progress. First contact will occur at 3:04 A.M., PST (6:04 A.M., EST); last contact at 7:02 A.M., PST (after moonset in the Eastern Time Zone). No clear-cut contacts may be observed in a penumbral eclipse, because the moon penetrates only the penumbra of the earth's shadow and the entire lunar disk remains illuminated throughout. Instead, a gradual reduction of the moon's brightness is observed, as if it were viewed through a dirty window. After the maximum apparent dimming has been achieved, the moon's brightness returns gradually to its normal appearance. Two other penumbral eclipses of the moon will occur this year, on July 17 and on August 15.

On the preceding pages, MRS. GOSSNER offers the second in her 1962 series — a survey of the celestial sphere.

To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.



north
northwest
west
southwest
south
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
DRACO
CEPHEUS
LITTLE DIPPER
NORTH POLE
POLARIS
CASSIOPEIA
Great Nebula
ANDROMEDA
Double Cluster
CAMELOPARDALIS
URSA MAJOR
LYNX
AURIGA
CAPELLA
PERSEUS
ALGOL
ARIES
PISCES
ZENITH
CASTOR
POLLUX
PLEIADES
GEMINI
15
12
The Beehive
CANCER
TAURUS
CETUS
CANIS MINOR
PROCYON
BETELGEUSE
ORION
MONOCEROS
Great Nebula
RIGEL
ERIDANUS
LEPUS
SIRIUS
CANIS MAJOR
PUPPIS
COLUMBA
TIMETABLE
February 1 11:00 P.M.
February 15 10:00 P.M.
February 29 9:00 P.M.
(Local Standard Time)

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Sea anemone *Anthopleura elegantissima,* above and to left of center, had not yet begun to divide when it was recorded in photo of the adjacent turban snail scraping algae from wall of aquarium.

ONE EQUALS TWO

A sea anemone achieves its plurality in singular fashion

By Clifford Davis

Inhabiting the world's oceans from tropical waters to the margins of polar seas and from coastal tide pools to byssal depths of as much as 30,000 feet are a thousand r more species of marine animals called sea anemones. 'heir plantlike name derives from the delicate, waving entacles the animals use to sweep minute sea creatures or ie debris of other animals' prey into their centrally located iouths. The tentacles also serve as a means of defense, nce they are equipped with poisonous, stinging cells. The ing of most species, however, is not severe enough to pro- uce more than a mild, tingling sensation in man, one of ie two chief predators of the anemone, the second being ie sea slug. Both men and sea slugs eat anemones.

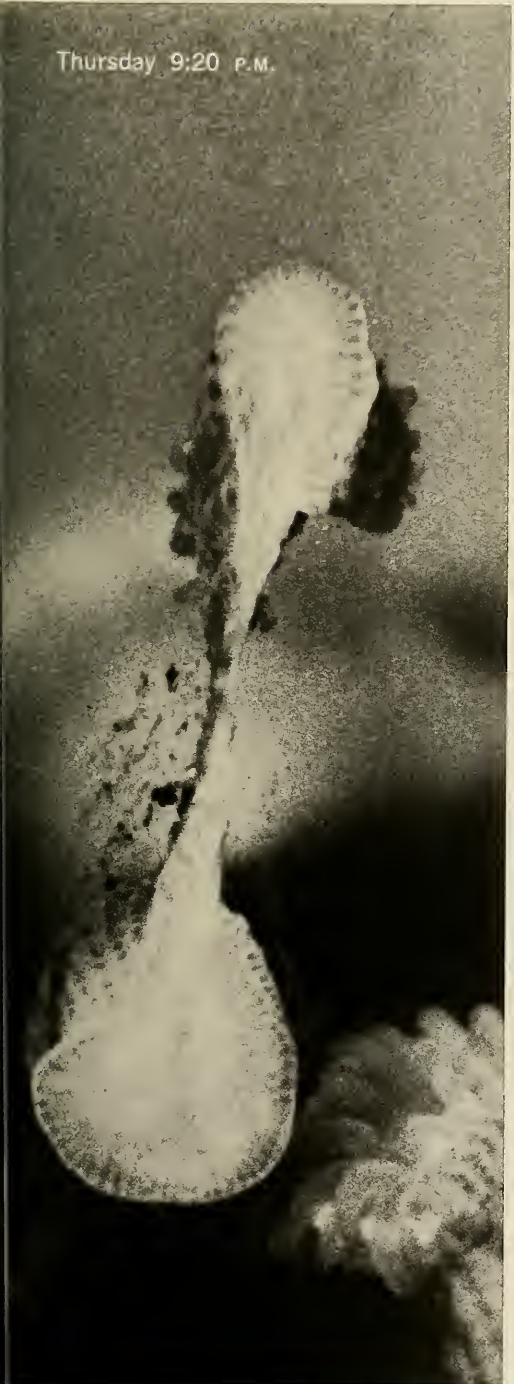
Structurally, most sea anemones have a muscular body apped with a flat disk, in the center of which is an elon- ated mouth surrounded by one or more circles of tentacles. ı tropical waters, anemones are often brilliantly colored, ut in temperate waters their colors are more muted, tend- ıg to white, tan, brown, pink, or green. Although no long-term studies have been conducted to determine the anemone's life-span in nature, one group of captive anemones survived nearly eighty years in a laboratory, and were believed to have been nearly ninety years old when they died.

Sea anemones may reproduce either in normal, sexual fashion—in tide pools the water is often rendered cloudy by the myriads of their ejected eggs—or by asexual means. In the latter case the animal multiplies by dividing in one of four ways: by longitudinal fission, budding, transverse fission, or pedal laceration. Shown on these pages is a photographic sequence that traces the longitudinal fission of an *Anthopleura elegantissima,* one of the commonly found sea anemones of the American Pacific coast.

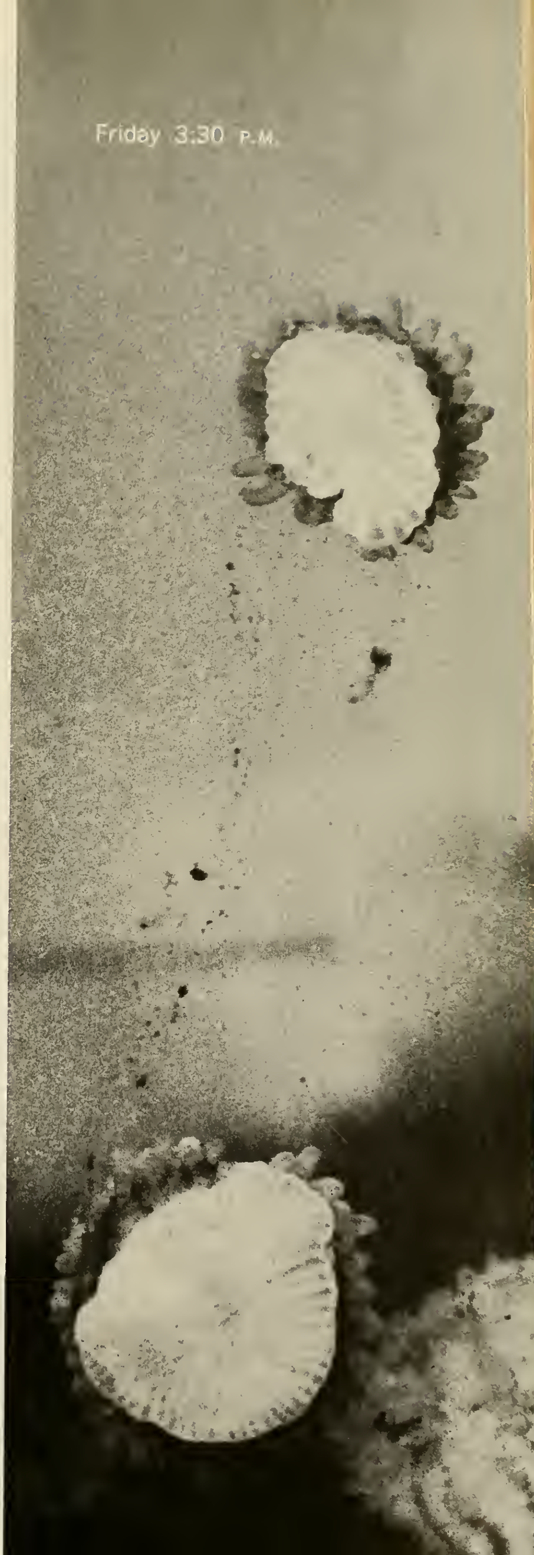
The division of this anemone occurred during an eight-day period in a ten-gallon marine aquarium that I had started while studying marine biology in the Department of Biology at Linfield College, McMinnville, Oregon. During my observation of the anemone's division, Leslie Braby, also a student at Linfield College, took the photographs.

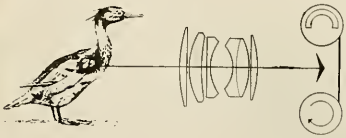
FISSION PROCESS probably began late Sunday or even early Monday. Alteration in anemone's shape is readily apparent.

TWO DAYS LATER, upper part of the anemone has thickened, while the middle section has become considerably thinner.



NEARLY APART by evening of seventh day, *above*, anemone divided completely, *right*, before 7:50 A.M. of eighth day.





NATURE and the CAMERA

A basic guide to close-up photography

By David Linton

For the layman who is interested in natural science, photography is the ideal way of creating a collection that needs no museum to house it. A surprisingly large proportion of such photography, however, involves objects small enough to require special photographic techniques. Whether the subjects be fossils, birds' eggs, meteorites, ice crystals, or flowers, the problems of close-up photography are the same.

Standard photographic techniques and equipment are designed for photographing objects the size of a man and larger. Smaller objects must usually be photographed from a closer viewpoint. Ordinary methods of measuring light and computing exposure are actually correct only when the camera is focused at infinity, but the error is negligible for working distances down to eight or ten times the focal length of the lens. (Focal length is a permanent characteristic of the lens, usually marked on the lens mount. It equals the distance from lens to film when the lens is focused at infinity.) At close range, the exposure must be increased to compensate for greater magnification. This is one reason why simple cameras often do not focus closer than three feet. Such cameras, if they use roll film in the popular 120 or 620 size, usually have lenses with focal lengths of 75 to 85 mm. (three to three and one-half inches). The three-foot limit is roughly equal to ten times this focal length, and is the nearest point at which normal exposures can be used.

At a distance of three feet, an 80 mm. lens on a 120 reflex camera will photograph a field about two feet square. To fill the frame with an object smaller than that, the camera must be moved closer to the subject. This involves three families of problems, which we will consider in turn. The three families are focus, exposure, and lighting.

To focus on an object closer than the normal limit of the camera, we must either move the lens farther away from the film or change the focal length of the lens. For simple cameras with non-removable lenses only the second choice is possible. It is done with extra lens elements called "close-up attachments," which fit over the regular lens as eyeglasses fit over the eye. These attachments are inexpensive and quite satisfactory. They do not require any adjustment in exposure as long as the lens is not moved farther from the film than usual. Such attachments work only within a limited range of distances, but several different ones can be interchanged or used in combination to increase their range. For twin-lens reflex cameras and for some range finder cameras there are also attachments that correct the view finder so that it will show what area is covered when the auxiliary lens is used. Even with these correcting devices, it is difficult to see just what the camera is getting and where the zone of sharp focus lies. That is the chief disadvantage of close-up attachments. Also, the image they produce is not always as sharp as that of a lens operating at the focal length for which it was designed.

A better way of obtaining a large image of a small object is to move the lens farther away from the film (and closer to the subject). This is easy to do with a view camera or press camera, especially if it has extra track and bellows. These cameras have ground-glass screens for focusing (thereby solving the problem of how to see what the camera sees), and are unquestionably the best choice for close-up photography of objects that do not move. They are heavy and difficult to set up, however, and may not be a good choice for work in the field or with live subjects.

Smaller cameras, particularly 35 mm. ones, are more maneuverable. If the lens can be removed, it can be set farther from the film by using extension rings, tubes, or bellows interposed between the lens and the camera body. Among small cameras, the single-lens reflex is the most convenient type for close-ups because viewing and focusing are done through the lens that takes the picture. Several possible sources of error are thus eliminated. Before the recent wave of popularity of single-lens reflex cameras, copying outfits were used with many standard range finder cameras. These accessories use a small ground-glass screen in place of the camera for viewing and focusing. Just before the exposure, the camera must be substituted for the viewing screen. This is a clumsy arrangement. The single-lens reflex accomplishes the same result with an almost instantaneous flip of the mirror, and is much more satisfactory.

On any camera that has removable lenses, a considerable magnification can be obtained by using a shorter-than-normal lens, even one designed for a smaller camera. The image of a mosquito will fill a 5- by 7-inch negative if a two-inch movie camera lens is used in place of the normal nine-inch lens. At ordinary working distances such a short lens would not "cover" the film (that is, the flat field in which a sharp image is formed would not be large enough), but in extreme close-ups the field, too, is magnified.

When the size of the image is to exceed the size of the subject, the lens should usually be mounted backward. This is because most lenses are designed to form an image of an object that is comparatively far away, and project that image onto a plane (the film) that is relatively close. Most lenses, therefore, are designed to have differing optical characteristics in "front" and "back." The front should face the longer of the two distances. Thus, if the film is farther from the lens than the subject is, the lens may give a better image if it is reversed so that its front faces the film. Test photographs should be made to see if the image is improved. Various bushings and threaded rings are available to hold lenses in the reversed position, or one can be made by any well-equipped camera repair shop. Unfortunately, only a few of the commercial close-up attachments provide for reversing the lens. Even fewer manufacturers provide any means for attaching a lens shade to the back of the lens when it is used in reverse, although the "press-on" type of adapter rings will work on some lenses. Shading the lens is just as important in close-up work as in any other kind of photography, and the photographer must devise a way to hold a shade in place, even if only a strip of masking tape.

Exceptions to the reversing rule are lenses designed specifically for close work, such as copying or engraving, and lenses of symmetrical design, with front and back optically identical. Enlarging lenses are designed for short-range work, but even so, they should be mounted backward. Since enlarging lenses do not have shutters, they may prove inconvenient on cameras where the exposure is ordinarily controlled by a shutter in the lens. In the absence of either a focal plane or a between-the-lens shutter, long exposures can always be controlled by turning the lights on and off or by re-

Numbers on scale are factors by which to multiply exposure indicated by a light meter when making close-up photos with a full-frame 35 mm. camera. Place scale in front of subject at same distance from lens, parallel to long dimension of frame. "Start" mark must touch one edge of frame seen in view finder. Last factor visible at opposite edge is correct exposure factor.

moving and replacing a lens cap. The latter method was good enough for Mathew Brady, but most photographers today consider it imprecise.

Modern 35 mm. single-lens reflex cameras have internally coupled automatic diaphragms. There is a button or lever inside the lens mount (the side usually toward the film) that closes the diaphragm to a predetermined stop. This button or lever is ordinarily actuated by a cam in the camera body when the photographer presses the shutter release. When such lenses are mounted backward for close-up work, the diaphragm is no longer automatic, but the button is on he outside, where it can be pushed manually just before the exposure.

At short distances and great magnifications any camera movement will be magnified. It is thus essential that the amera be firmly mounted on a tripod or lamp. Two tripods—one under the camra body and the other under the lens—re even better. No camera support has et been invented that is really satisfacory for close-up work in the field.

In any close-up where the size of the mage approaches the size of the subect, the best focusing procedure is to eave the camera and lens stationary and nove *the subject* into focus. In fact, it nay be impossible to find any point of harp focus if the lens is moved back and orth in the usual way. This is because noving the lens closer to the film simulaneously moves it farther from the subect. The effect is negligible at normal istances, but may completely defeat the ttempt to focus on a close subject.

Many natural subjects, of course, canot be moved, so the next best method is move the camera and lens as a unit. xtension bellows of "double track" degn are to be preferred over "single ack" models because they have tripod onnections on the track that allow the amera and lens to be moved either indeendently or together.

Depth of field (the distance between e nearest and farthest points that are sharp focus) is extremely shallow in ose-ups. The lens diaphragm must usuly be stopped down to a very small erture to bring all of the subject into cus. This limitation requires either a ry long exposure or a lot of light, or oth, and it compounds the already acute oblem of close-up exposure.

The exposure that is indicated by an posure meter is, as mentioned above, plicable only at "normal distances" .e., more than ten times the focal ngth of the lens). At shorter distances e indicated exposure must be multiied by a factor that increases very pidly as magnification is increased. is factor is usually called the "bellows tension factor" although it really relts from the magnification and not

Diffused light, achieved with a "tent," hides texture of chipped stone arrowhead.

Lights at each side restore texture, in part, but cause ugly, distracting shadows.

Black background fails to hide shadows entirely and makes subject look too light.

from the extension of the bellows. The magnification involved is in the size of the image on the film, as compared with the subject itself. Further magnification may be introduced later in enlarging, but it does not affect the exposure factor. When the image produced on the negative is the same size as the subject, the exposure indicated by a meter must be quadrupled. For an image twice as big as the subject. the exposure factor is nine!

There are several formulas for computing factors for other magnifications. They involve the lens-to-film distance and the focal length of the lens, but it is not necessary to use them. All that really matters is the size of the image in relation to the size of the subject. A few years ago, some genius at Eastman Kodak devised a little ruler that gives exposure factors directly for any camera with ground-glass viewing. A target two inches across is temporarily placed next to the subject, the image of this two-inch target on the ground glass is measured with the "ruler," and the answer is read directly in exposure factors. This ruler is included in the Kodak Master Photoguide, available at any camera store.

On 35 mm. cameras, the ground glass (if there is one) is too small to be used for making measurements. But a similar ruler can be used at the subject to find exposure factors for various sizes of the field (see margin. page 64). If, for example, the area included in the picture measures three and one-half inches long at the subject, the exposure factor is two, and the exposure indicated by a meter should be doubled. For greater magnification, or for cameras that are not 35 mm. size and have no ground glass, a little cardboard "Effective Aperture Computer" is available. It is a specialized, circular slide rule. As a last resort, the formula (given in most photographic handbooks) can be computed on paper.

Effective lighting must reveal the significant features of the subject without looking unnatural. Also, of course, it must provide enough illumination to expose the film properly. A third function, in close-up work, is to enable the photographer to see what his camera is getting and when the image is in focus. These requirements, which are given in order of importance, sometimes conflict. The photographer who works out of doors and uses only sunlight is not any less responsible for the lighting in his pictures than the photographer who stays home and uses floodlights. In no case should the lighting intrude.

Photographers who specialize in wildlife consider it unsporting to photograph animals that have been tamed or confined in any way. They do not seem to mind, however, if the light in their pictures comes from such an angle that it could not possibly be natural. In nature, light usually comes from above, but seldom from directly overhead. About half the time the dominant light source is *behind* the subject. There is usually light of lesser intensity coming from other directions, but *never* are there two light sources of equal intensity. The same natural pattern should be followed in lighting a photographic subject. However, film does not have as great a range of sensitivity as the eye, so shadows in the scene should not be as dark nor highlights as bright, comparatively, as they would be found in nature.

The lighting of close-ups is by far the most difficult part of this sort of photography. Since each subject presents individual problems, great patience and ingenuity are required. A light or reflector is moved slightly and the result is studied. Then the light is moved a little more; there is no other way. There are, however, a few tips that may reduce the time spent in arranging the lights.

Subjects with surface texture should be lighted from an angle; translucent subjects should be lighted at least partly from behind. Shadows should never be allowed to interfere with the natural contours of an object, and each object should be separated both from others and from the background. A subject with a glossy surface should ordinarily show a few reflections to indicate its character, but surface reflections should never obscure the color and shading underneath. One universal rule of thumb is that the more light sources there are, the more problems will be created.

Any light source can be used for close-ups. In the field, excellent work can be done with sunlight alone if reflectors, mirrors, and even small lenses are used to control it. Flash and electronic flash are also used, but they require extra care because the photographer cannot see and judge their effect before he takes the picture. The usual guide numbers used for determining exposures with flash will not work for close-ups because the bulb and reflector do not act as a point source of light when they are very close to the subject. Special, reduced guide numbers must be derived by actual test.

With subjects that move, however, flash and electronic flash have the advantages of stopping motion and of not producing very much heat. For subjects that do not move, these devices present the possibility of building up an enormous amount of light by repeating the flash as many times as necessary.

Let us try to apply the precepts above to an actual situation—a picture of an arrowhead one inch long. Since our purpose is to make a scientific record, we will photograph it "squarely"—with the film parallel to the chief plane of the subject—so that no part of the object

David Linton's by-line has appeared under photographs in all the nation's leading magazines. His camera column is a regular feature on these pages.

:FFECTIVE LIGHTING reveals arrowhead's urface details and its translucent edges.

endered larger or smaller by perspec-ve. Therefore, we put the arrowhead on piece of white paper on a table and set ie camera, pointing straight down, di-ectly over it. Now we can start lighting.

First we look through the viewer and enter the arrowhead in the frame. It ooks pretty good, so we decide that per-aps diffused lighting will be best. The dinary room lighting isn't quite right, owever, so we decide to build a "tent." his is an enclosure, usually of white iper, that surrounds the subject and flects light from all sides. We wrap a ece of paper into a cone with the lens med—through a hole in the apex—at e arrowhead in the center of the base. iere isn't room to put any lights inside, we shine a floodlight through the per from the outside.

The arrowhead stands out nicely, but w we find that the texture of the sur-e has disappeared.

Folding our tent, we silently go back direct lighting. We shine a floodlight m one side, and find that at a low gle the texture is brought out in stark ief. The side away from the light, wever, is hidden in shadow. We bring another light on the dark side and : it lighted up, too. But now we see tracting shadows on the background. move the lights around, trying to dis-er a position that will eliminate the dows without eliminating the surface ture. If we can only put the shadows ere they will be hidden by the subject lf, the shadow problem will be solved. ally, we discover that as we move the its closer to the lens the shadows get iller. In order to eliminate them com-tely, though, the light and the lens ild have to be at the same spot. This iot quite as impossible as it sounds, ause doughnut-shaped light sources exist. Electronic flash tubes are made circular form, with provision for the to look through the center of the g. Fluorescent tubes are also made in

circles. and a reasonably ingenious photographer can make a reflector for one from a cake pan of the type used for angel food cakes.

A more common solution is to use a reflector of white paper, cloth, or metal foil and "bounce" the light from it onto the subject. The lens can be stuck through a hole in the reflector. Of course, the lens must be shaded from direct light to avoid reflections inside the lens that might interfere with the image.

If we use a light at the camera axis to photograph our arrowhead. we will find that the shadows have been conquered, but that the texture is gone, too, and the whole picture looks dull. Very well. Let us go back to the two-light setup. We can improve it somewhat by using a reflector (a sheet of white cardboard) in place of the second light. This softens some of the shadows and automatically makes the light on one side of the subject dominant—a situation that generally looks more natural than evenly balanced lighting. The shadow cast by the main light is still disturbing, however, and at this point there is usually a temptation to try to drown the shadows by making the background black. If we try it, we will find that the black background makes the subject look too light. the texture becomes less apparent, and the shadows are still visible, anyway.

The next move is to put the arrowhead on a sheet of glass and put the background under it, far enough below so that the shadows will be outside the picture. To make sure that they are outside, we temporarily focus the camera on the background and check. Then. focusing again on the subject. we note with satisfaction that the texture is brought out nicely and the shadows have been eliminated. However, the quality of the material doesn't quite emerge. The stone is actually translucent near the edges where it was chipped very thin, and it has a hard. shiny surface.

To emphasize these qualities we make two more changes in the lighting. First. we fasten a small mirror from a lady's handbag just outside the picture so that it reflects a beam of light across the highest part of the arrowhead, causing a few bright highlights that perk up the surface and show how hard and shiny it is. Then we take away the paper background and replace it with a sheet of opal glass (or plain glass covered with tracing paper). We put another light behind the background and find that by moving it closer or farther away we can make the background lighter or darker and can bring out a bit of the translucent quality of the object.

Now we are ready to take the picture. We measure the size of the field included in our frame and determine the exposure factor. We turn off the background light while we take a meter reading, to avoid misleading the meter with light from the background. Then we stop down the lens diaphragm and examine the image carefully. It is so faint that it is hard to see anything. but our eyes adapt. and finally we see a bright silver streak across the middle of the picture. We look at the subject again—no streak. Then, at last, we see it. It is a reflection of the front of the camera in the glass on which the subject rests. We didn't see it before because it was out of focus until the lens was stopped down. We get a piece of black paper. cut a hole in the center, and slip it over the lens.

When we finally open the shutter (using a cable release to avoid jarring the camera) it seems like an anticlimax, but that is the way good close-ups are made.

This list details the photographer, artist, or other source of illustrations, by page.

COVER—Marineland Studios
3—AMNH
4—Joseph Sedacca
8-13—Lee Boltin
14-18—G. Stuart Keith
19—AMNH
20-29—Philip Newman
30-39—Winthrop N. Kellogg, except 33 bot. and 36-37—Enid Kotschnig
40-47—Peter Merom
48-53—Fritz Schremmer
55-57—AMNH Archives
58-59—Sky Map, after Henry M. Neely
61-63—Leslie Braby
64—AMNH
66-67—David Linton

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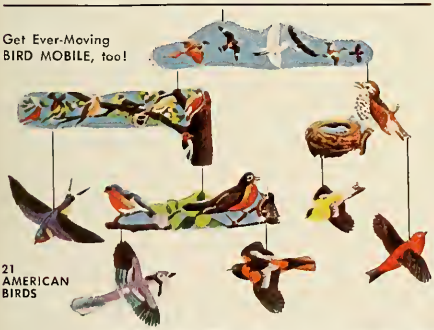

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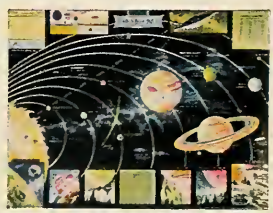

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COVER: Found in a tomb near Carthage, this colored glass amulet dates fro the fourth century B.C. The translucent representation of a bearded man's fa is less than two inches long. It was worn on a chain and was meant to prote the wearer from evil powers. The figure's exaggerated eyes might have been t seat of its supposed magic properties. Stylistically, the amulet shows Hellenist influences; earlier Carthaginian "charms" seem more Egyptian or Near Easter The cover painting was executed in oil by Hans Guggenheim, whose illustratio grace Dr. Kenan Erim's discussion of ancient Carthage, which begins on page 5

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Reviews

Two views of our lan(

By Jack McCormick

The Continent We Live On, by Ivan T. Sanderson. *Random House, $20.00; 300 pp., illus.* Our National Park Policy, by John Ise. *The Johns Hopkins Press, $10.00; 701 pp.*

During the past two decades, the phrases "population explosion" and "urban sprawl" have evolved from catchwords into accurate names for the results of human fertility, extended life expectancy, and the greater demand for individual living space. Simultaneously, there has developed an increasing number of proponents for the preservation of wilderness and natural areas, and for the enjoyment of open spaces in all types of parks, and other tracts kept free of houses, shopping centers, factories, and similar developments. Each day, however, such areas become scarcer and more expensive to acquire.

Coupled with this increased interest in the conservation of open space and natural areas is a growing desire for knowledge about the location, the natural features, and the biota of such areas. Two recent books portray America's natural features from different viewpoints and through different mediums.

John Ise, Professor Emeritus at the University of Kansas, makes a realistic and somewhat pessimistic analysis of the establishment, evolution, and future of our greatest system of preserved natural areas—our national parks—in a scholarly, well-documented book. This is an absorbing account both of the discovery and of the natural features of our various national parks and memorials, and of the struggles to acquire and maintain them.

In striking contrast to Dr. Ise's superb but unadorned text is the beautifully illustrated volume entitled *The Continent We Live On.* As an example of excellence in landscape and wildlife photography, combined with fine printing and craftsmanship, this volume is unsurpassed. Regrettably, the book is badly marred by its accompanying text—the work of Ivan T. Sanderson, who is rapidly rising to the office of high priest of nature fakers. His occasionally lucid but generally mediocre text is a case study in faulty interpretation, undocumented claims, fictitious awe, and totally unnatural history.

There is such a contrast in quality b
tween word and illustration that it
difficult to think of the volume as "Iva
Sanderson's book." It is easier to belie
that Random House has a conscientio
picture editor who spent considerab
time locating and assembling some of tl
most outstanding landscape photograp
available. To that anonymous individu
much of the credit should be given f
the value of this book.

Generally, a reviewer welcomes tl
opportunity to compare the ideas of tw
authors who are dealing with simil
material. He can air their differences
opinion, and point pleasurably to co
cepts about which they agree with o
another—or with the reviewer. In the ca
of these two books, however, such a co
parison would be a travesty. *The Co
tinent We Live On*, therefore, will
sampled only briefly, so that some of tl
stimulating concepts in *Our Nation
Park Policy* can be examined at lengt

One surprising aspect to be noted r
garding the approximately 235 fi
photographs (of which 109 are in colo
is that only three have any discernab
trace of man or his artifacts. All tl
others are unmarred by houses, pow
lines, vapor trails, highways, or charmi
models in bright clothing. Only a few
the photographs are obviously posed
make use of dead, propped-up specime
or museum displays. (One example
the last—a picture of a jack rabbit—w
taken in The American Museum
Natural History, but it is not proper
captioned or credited.) As a result, tl
bulk of the pictures form a beautif
portfolio of America's natural landscap
which may justify purchase of the boo

Even Mr. Sanderson's introducto
remarks, however, indicate his lack
familiarity with his chosen subject. I
makes the baseless claim that "not ha
a dozen states . . . have so much as a veg
tation map of their territory. . . ." To tl
reviewer, who presently is wilting b
neath the burden of cataloguing mo
than a thousand published vegetati
maps of various parts of North Americ
this statement is ludicrous. Althoug
they vary in quality, scale, and conce
such maps are available for every sta
and every portion of North America.

The legion of erroneous statements in he text permits mention of only a few :xamples. The author states, early in he work, that a body would weigh about 1 per cent more at the North Pole than t the Equator, owing to the difference n centrifugal force produced by the arth's rotation. Actually, the increase in veight would be less than 0.4 per cent. gain, he observes that an iceberg melts nore rapidly *below* the water surface han above, and therefore rises higher n the water as it melts. Anyone with an lementary familiarity with Archimedes' aw would know this to be the reverse of hat occurs. Actually, an iceberg rises in ie water because its exposed surface ielts or abates more rapidly than its subierged sections. As weight is removed rom above, the pressure of the water rces the ice upward until only enough beneath the water to displace a volume f water with a weight equal to that of ie entire ice mass.

But there is more. Steam, it is said is ie gaseous phase of water, whereas actually is a suspension of liquid drop-ts.The Laurentian Shield, the major :ologic feature of central and eastern anada, is termed a "horst," although horst, by definition, is a vertically ele-ited fault block. The Yukon's St. Elias ange is modestly said to have a peak evation of more than 18,000 feet; actu-ly, its highest peak—Mt. Logan—reach-a proud 19,850 feet. Glacier Bay is ferred to as a National Park of 230,000 res, while in reality it is a National onument of nearly 2,300,000 acres. The llest redwood is said to have stood 340 et in height, but the tallest known red-od—the Founder's Tree—was 364 feet ien last measured, and is still growing. Let us also select at random a few amples of Mr. Sanderson's unnatural story. We learn at the master's knee at the major glacial periods were *not* nes when ice moved over the land, but ien, instead, "the land must have ved in and out under the polar ice...." iother bit of lore, designed to awe the wary reader, relates that desert plants ave developed" spines for the "pur-se" of discharging surplus static elec-city, thus becoming—according to the thor—lightning rods in reverse. This plains the "strange crackling sounds" d the mysterious lights that people th Mr. Sanderson's imagination seem one to encounter in the desert.

The usual errors in popularized nature counts written by ill-informed or care-s authors also occur. Plants *breathe* ough pores located on the underside the leaves. Cacti are the dominant ints of the desert and, if removed, uld leave a barren or "sterile" void. The reader should also be cautious of Mr. Sanderson's glossary. Among other errors, a saprophyte is there defined as "A plant that grows upon but is not parasitic on another plant."

In addition to its mistakes, much of the text of *The Continent We Live On* is inappropriate. Although the book is supposedly designed as a description of the natural landscapes of North America, a goodly portion of the text and many of the illustrations are devoted entirely to the mammals of North America. However, it must be conceded that Mr. Sanderson is more accustomed to discussing mammals than geologic processes, landscapes, and vegetation patterns. It is at least a relief to find that the strange, humanoid creatures which, according to Mr. Sanderson's previous writings, are roaming undiscovered through our western wildernesses, find no mention here.

On the other hand, so much history, so many facts, and such a variety of suggestions, opinions, and predictions have been crammed into Dr. Ise's book that it would require a reviewer of rare qualifications properly to evaluate and combine all of this work's aspects.

Few of us need to be reminded that we live in a time of rapid changes in ways of life. In about a century, we have progressed from horse and buggy to space probe, from heliographs and smoke signals to instantaneous communication by telephone, radio, and television, and from a life expectancy of little over 40 years to one of nearly 70. Several factors have precipitated the modern need for action to preserve America's remaining natural areas and to provide more recreational lands and facilities. Among these factors are the rapid growth of our population, the rise in real income, the availability of more leisure time, the rapid disappearance of open land—particularly around metropolitan centers—and the increasing mobility of our population. At the present, we have too few natural areas, insufficient recreational lands in our public parks, and a very inequitable geographic distribution of park lands. An opinion often is voiced, however, that we have too much land "tied up" in parks or otherwise kept "unproductive." Dr. Ise's comment on this statement is that, even if we had twice as much park and wild land, it would not be necessary or desirable to forfeit any of it for other uses. This is because the demand for outdoor recreational outlets is increasing much more rapidly than the supply, whereas our ability to bring forth produce from the land is increasing more rapidly than the demand for those products. We certainly need no land bank for surplus park land.

The difficulties of maintaining any area in a totally natural state are briefly considered by Dr. Ise. A major problem here

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An ecologist, Dr. McCormick is with both the Botany and Polar Research Departments at Ohio State University.

is that no area with artificial property boundaries is likely to be a self-sufficient biotic area. This situation is aggravated because each year the boundaries of wild land are circumscribed more closely by the intrusion of man and his homes, motels, farms, ranches, and other activities in surrounding areas.

Some of the animal inhabitants of a wild area will always range outside its boundaries, while animals with homes elsewhere will always be temporary visitors to such an area. Efforts to eliminate predators may have reduced these animals so effectively that the grazers and browsers will reproduce at a rate that decimates the available food plants. When this occurs, many of the nonpredators die of starvation and disease. The surviving population is usually much smaller than the original population because the recovery of the food plants, or range, is exceedingly slow.

Although Dr. Ise does not mention the as yet unknown effects of radioactive fallout and the possible direct effects of nuclear blasts in the event of a war, he does mention that man has become quite efficient in the protection of natural communities from fire and insect attacks. This efficiency, however, already is producing drastic changes in natural communities. Some communities, for example, require fire for their establishment or perpetuation. Insect epidemics also seem to play a major role in the perpetuation of some forest types. A much more important effect of insect control, however, results from control measures themselves—usually broadcast applications of poisons—which kill not only the destructive pests but also many other kinds of insects, spiders, mites, and even birds, fish, and mammals. Admittedly, it is difficult to let oneself stand by and observe the progress of a fire through a natural area or to watch the slower progress of an insect epidemic. But, more often than not, fire and insects and diseases are an integral part of the ecological regime of a vegetation type. Protect the vegetation from them, and interactions between the plants themselves will change the vegetation. It would be impossible, for example, to preserve many kinds of pine forests if fires were eliminated. Even the giant sequoia would eventually be replaced by pines, incense-cedar, and firs if fires did not periodically kill these competing trees and provide bare soil for sequoia reproduction.

Our preserved natural areas already are besieged by proponents of the "multiple use" philosophy of land management. Most of the multiple-users argue that large, "overmature" trees, or trees blown down by the wind, or killed by fire, lightning, insects, or diseases should be removed from natural areas—either, frankly, to provide lumber rather than going to waste, or to "protect" the areas by reducing insect-epidemic or fi hazards. Usually, they also comment th the remaining forest would be render more attractive, because many crooke malformed trees would be removed ar ultimately would be replaced by youn straight-trunked trees. Although mar of these arguers are not motivated l selfish, economic interests, no few a Those whose views are altruistic overlo one fact—they are actually recommen ing the artificial alteration of biotic co munities that have been placed und protection specifically to prevent ju such artificial alterations. We certain cannot learn much about the workin of nature if we begin to substitute o own methods for nature's.

Looking far into the future, Dr. I thinks that our parks and preserv areas are relatively secure as long there is a sufficient supply of other la for agriculture and commercial timb production. However, if the present ra of population growth continues, we m find that these preserved areas ha merely been "banked." As the deman increase for timber, for water (to be us for irrigation, for hydroelectric pow and for domestic and industrial pu poses), and for more grazing and cr land, there may be a commercial invasi of preserved areas. Such an invasion m become irresistible if it is essential to t survival of our population.

The most immediate threat to our r creational and natural areas, however, not this exploitation. Rather, it lies in t growing popularity of these areas a the opportunities they afford for scer enjoyment and outdoor activities su as camping, hiking, boating, and skiir The preserves may deteriorate simp because of overuse by "swarming hord of vacationists." By 1966, some 80 m lion visitors will throng to our natior parks alone. By the year 2000, this to may mushroom to 300 million or ev more. The use of other kinds of reserv lands should increase proportionate

Throughout Dr. Ise's book, one feels is a miracle that our nation has *any* p served lands. Americans always ha been and still are too indifferent to o natural heritage. A few often unapp ciated individuals have fought unt battles against tremendous numeri and financial odds to secure, mainta and enlarge our systems of preserv lands. To assure the perpetuation a extension of these areas, every interest citizen must contribute in some for The numbers of the interested are st relatively few, although their numb are increasing. Dr. Ise has suggested appropriate slogan that might beco the watchword of wilderness lovers w shudder at the sight of the not alwa necessary rape of the American lan scape by bulldozer, plow, and saw: "G bless America, and let's save some of i

N BRIEF

ɔMADS AND EMPIRE BUILDERS, by Carle-
n Beals. *Chilton Company, $7.50; 322*
›., illustrated.

N an attempt to fill what he considers
a serious gap in our knowledge of the
eat continent to the south of us, Carle-
n Beals has written a book that at-
mpts to describe South America's
any, multiracial cultures in all their
versity. The writing seems hurried and
temperate at times, especially when
e author discusses the various theories
racial origin in South America. And,
an effort to cover all the cultural his-
y of the inhabitants of so vast an area,
great deal of summarizing is necessary.
a result, too much is packed into too
tle room and, for the reader, one cul-
e begins to diffuse into another. The
thor does succeed, however, both in
esenting quantities of information and
suggesting the variety and cultural
alth of our American neighbors.

ANT HUNTERS IN THE ANDES, by T.
rper Goodspeed. *University of Cali-*
nia Press, $7.50; 378 pp., illustrated.

R. GOODSPEED'S book is an account
of a number of expeditions to Peru,
ile, and Argentina undertaken by per-
nnel of the University of California's
tanical Garden between 1935 and
58. Their findings should be of interest
most botanical travelers in these re-
ns. The author offers much informa-
n concerning the environment and cus-
ns of life in the Andes, but the mate-
is so diffuse and the style so wooden
t the book is hard climbing indeed.

E CLOUD FOREST, by Peter Matthies-
. *Viking, $6.50; 280 pp., illustrated.*

ETER MATTHIESSEN crossed the Andes
nine times—not always by intention—
l traveled by boat, raft, plane, foot,
. and railroad to cover most of the
essible parts of South America, and
ne of the "inaccessible." Finally, hav-
survived a horrendous journey to the
pical interior of Peru, he was shown
uge, fossilized animal jaw, which be-
ne the subject of much subsequent
troversy. The author's style is urbane
his observations clear and evocative.
deep interest in natural history is a
n to the reader, since it allows him
name a majority of the animals, and
ny of the plants, that he encountered.
Matthiessen also has a wry and
etimes exasperated interest in his
ow man. As were the best of explor-
he seems led on by something below
beyond the surface of things—per-
s typified by a lost and beautiful
am he describes as having the "inner,
terious quality of the jungle." Doubt-
, as he suggests, Mr. Matthiessen has
left this deep, violent, and indolent
tinent for good.

CRUSADE FOR WILDLIFE, by James B. Trefethen. *The Stackpole Company, $7.50; 377 pp., illustrated.*

THIS book was commissioned by the Boone and Crockett Club, of which Theodore Roosevelt—America's first great conservationist in the public realm—was a founder. It is, therefore, partly concerned with giving an account of the club's history, which involves the American game hunter's relation to the conservation movement. Mr. Trefethen also provides a general history of conservation in America from the time of Roosevelt's arrival in the West as a young man to the present time.

WATCHERS AT THE POND, by Franklin Russell. *Alfred A. Knopf, $4.50; 265 pp., illustrated.*

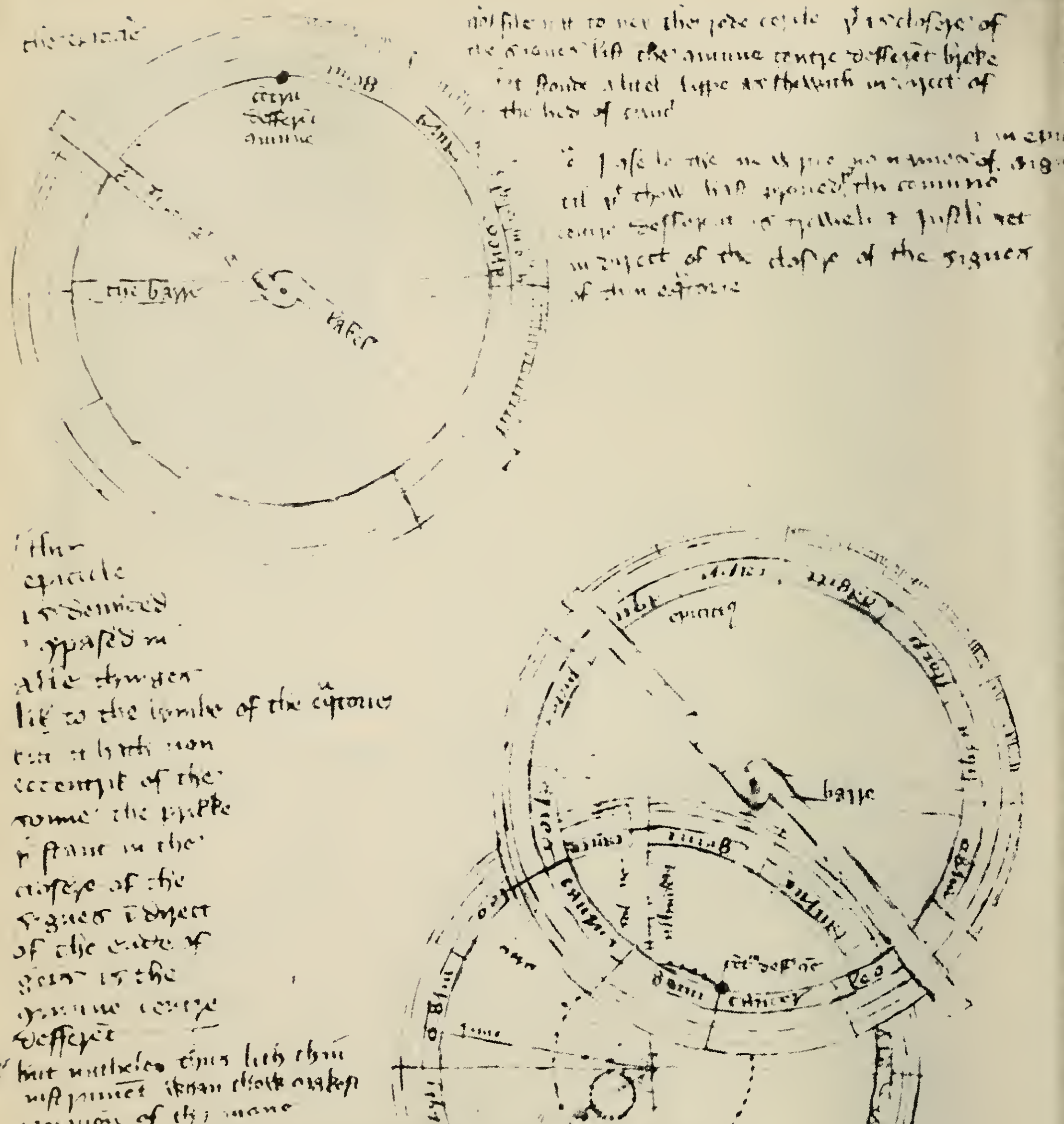
MANY books have been written on the subject of a pond's natural history in the cycle of a year—both in general and technical terms. Few, however, have managed to include as much lively detail as this one. Sometimes the fecundity and violence that the author reveals seem too simply concentrated, although he manages at the same time to suggest the vast area and the context of space and time in which the life and death of a pond take place. This is, in any event, a book packed with action for the general reader; rich in information and as exciting a narrative as one will find in any work of fiction.

SIR HUBERT WILKINS, by Lowell Thomas. *McGraw-Hill, $5.95; 296 pp., illustrated.*

THIS biography by Lowell Thomas is the story of the late Sir Hubert Wilkins, a polar explorer famous for being the first to attempt navigation under the Arctic ice with a submarine. Although it relates the life of a man who had more than the usual share of adventures, the book remains somewhat characterless. But it has the virtue, if such it is, of modesty and simplicity.

THE LONELY LAND, by Sigurd F. Olson. *Alfred A. Knopf, $4.50; 273 pp., illustrated by* Francis Lee Jaques.

THIS is the story of a modern canoe trip to the wilds of Canada, following the routes of the legendary *voyageurs* along the Churchill River in Saskatchewan. The author and a party of five men, prominent in public life, undertook this often dangerous journey, as one of them put it, "to iron out the wrinkles in my soul." They did not flinch before the rapids and took the most difficult portage in their stride. This is a well-unified, forthright book, which manages to convey a strong sense of the quality of the wilderness to the north of us that still deserves its name.


Cancer
Leo

Unworldly Mechanics

The early artificers of astronomical models served science well

By Derek J. de Solla Price

Any schoolboy knows Chaucer, but a much smaller number of students is aware that the best medieval :nglish book on an astronomical instrument is Chaucer's *'reatise on the Astrolabe*, written in 1391. My own interest n early scientific instruments has been great for many ears. Having had the privilege of constant access to the reat manuscript collections of Cambridge University not ›ng ago, I made a point of trying to examine every available medieval text that contained something about such ıstruments. After some months of relatively trivial result, nd at a point about halfway through my check list, forıne smiled for me. At the Perne Library of Peterhouse—ıe oldest Cambridge library—there was but one noteorthy item dealing with instruments. The catalogue escribed this as a tract, Latin *incipit* cited, "on the conruction of an astrolabe (?)." It was a rather dull volume, 'aditionally attributed to an obscure astronomer, and probbly had hardly been opened in the last five hundred years.

As I opened it, the shock was considerable. The instruıent pictured there was quite unlike an astrolabe—or ıything else immediately recognizable. The manuscript self was beautifully clear and legible, although full of asures and corrections (exactly like an author's draft 'ter polishing—which, indeed, it almost certainly is). bove all, nearly every page was dated 1392 and written Middle English instead of Latin. My high school had ıd a mad English teacher who, instead of spoiling Shakeeare, taught us Old and Middle English for a year, so rtuitously I was not completely unprepared for the task reading this work with some understanding.

The significance of the date was this: to find another ıglish instrument tract dated in the year following ıaucer's work was like asking "What happened at Hastgs in 1067?" The conclusion was inescapable that this ‹t must have had something to do with Chaucer. It was exciting chase, which led to the eventual conclusion ıat this was very probably a second astronomical tract our great poet—and, moreover, the only work that exed in his own handwriting.

By the end of this research I was considerably more niliar with the history and structure of the "planetary uatorium"—the instrument that it seems Chaucer had scribed as a companion piece to his astrolabe. This pair instruments was to a medieval astronomer what a slide le is to an engineer. The astrolabe was used to calculate : positions of the stars (it could also be used for simple servations, just as a slide rule can function as a straight ‹ge), while the equatorium was used to calculate the sitions of the planets among the stars.

This new background in the early history of other instruments led me to realize that the astrolabe and equatorium occupied a strategic place in history. They were by far the most complicated and sophisticated artifacts throughout the Middle Ages. Their history seemed to extend back continuously in that period, although it was uncertain whether they should be ascribed to a Hellenistic or just an early medieval origin. At the other end of the scale, they survived in some form or other until the sixteenth and seventeenth centuries, becoming then involved with the astronomical clocks of the Renaissance and the orreries and planetariums which, respectively, had such a spectacular vogue in the eighteenth and twentieth centuries.

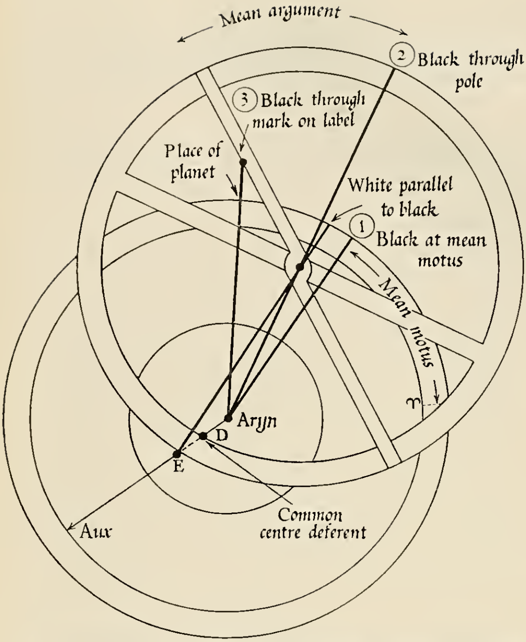
Here one was fishing in very rich waters. The specific task at hand was to see whether the astrolabe and equatorium would contribute to what was surely a very complex and unsatisfactory state of knowledge of the origin of these later astronomical showpieces. They heavily influenced the thought of such people as the theologian Paley, the scientist Boyle, and the poets Dante and, of course, Chaucer. They pushed philosophy toward mechanistic determinism. Put in this setting of the history of science, an even larger task seemed to emerge: one that is fundamental for our understanding of modern science.

This larger task concerns an appreciation of the fact that our civilization has produced not merely a high intellectual grasp of science but also a high scientific technology. By this is meant something distinct from the background noise of the low technology that each civilization and society has evolved as part of its daily life. The various crafts of the primitive industrial chemists, of the metallurgists, of the medical men, of the agriculturists—all these might become highly developed without presaging a scientific or industrial revolution such as we have experienced in the past three or four centuries.

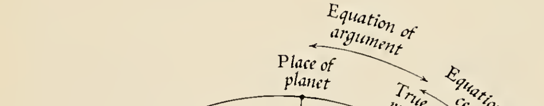
This high scientific technology seems to be based upon the artifacts produced by and for scientists, primarily for their own scientific purposes. The most obvious manifestations of the technology appeared in the seventeenth century, when all sorts of complex scientific gadgets and instruments were produced and proliferated to the point where they are now familiar as the basic equipment of the modern scientific laboratory. It is, indeed, the story of the rise of modern experimental science. Curiously enough, the movement does not seem to have sprung into being in response to any need or desire on the part of the scientists for devices they might use to make experiments and perform measurements. Galileo and Hooke extended their senses by telescope and microscope, but it took decades before these tools found further application.

On the contrary, it seems clear that in the sixteenth and earlier centuries the world was already full of ingenious

·TAIL OF EQUATORIUM is seen at left. The manuscript of ›ich this drawing is a part has been attributed to Chaucer.



Workings of equatorium for computing longitude of major planets is shown, *above*. Supposedly Chaucer learned about instrument from a Latin translation of a script in Arabic.



Ptolemaic means of calculating position of major planet, *above*, parallels the geometry of the equatorium. Scholars used astrolabe for star positions, equatorium for planets.

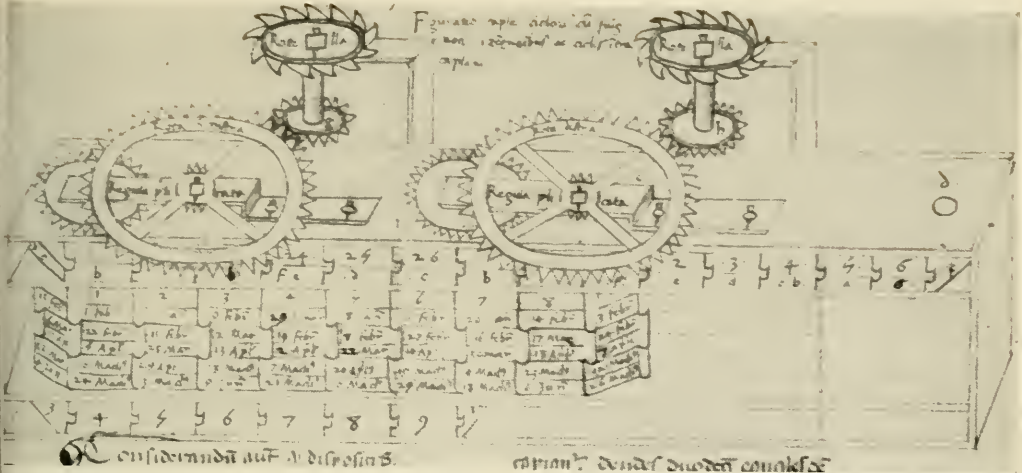
artisans who made scientific devices that were more won drous and beautiful than directly useful. Of course, many of the things, to be salable at all, had to be useful to a point. Consider, for example, the clock. It certainly had some use in telling the time a little more accurately than common sundials, but one gets much more the impression that even the common domestic clock, not to speak of the great cathedral clock, was regarded in early times more as a marvel and as a piece of conspicuous expenditure than as an instrument that satisfied practical needs. The usefulness, of course, developed later. Eventually, the artisans became so clever, and were producing such fine wares that public and scientist came to them to obtain not only clocks but also a whole range of other scientific devices

It seemed, then, that given the clockworks of the sixteenth century, one could proceed in a reasonably continuous historical understanding to the advanced instruments built by Robert Hooke for the early Royal Society and from that point by equally easy stages to the cyclotrons and radio telescopes of today's laboratories and to the assembly lines of Detroit. The problem was to account for the highly complicated clockwork and the development of its ingenious craftsmen in the sixteenth century.

Now, the history of the mechanical clock is as peculiar as it is fundamental. Almost any book on the history of time measurement opens with a pious first chapter dealing with sundials and water clocks, followed by a chapter in which the first mechanical clock described looks recognizably modern. The beginning is indeed so abrupt that it often seems to me that the phrase "history of time measurement" must have been expressly coined to conceal from the public the awful fact that the clock (as distinct from other time-telling devices) *had* no early history.

It is even worse than this. The very earliest mechanical clocks we know are the magnificent astronomical show pieces, such as the great clocks of Strasbourg Cathedral and Prague. In fact, the earliest of them all, a clock built by Giovanni de Dondi in Padua in 1364, is by far the most complicated of the series. It contains seven dials showing each of the planets and all sorts of other astronomical data, with an extra, rather inconspicuous dial that tells the time. It uses intricate multiple trains of gear wheels, even with pairs of elliptical gear wheels, link motions, and every conceivable mechanical device. Nothing quite so exquisite mechanically was built again, so far as we know, until a couple of centuries later. Even today a more cunningly contrived clock would be hard to find.

If one begins the history of the clock with this specimen it is plain that the art declines for a long time thereafter and that a glorious machine that simulates the design of the Creator by making a model of His astronomical universe is eventually simplified into a device that merely tells the time. Thus, one might well regard the modern clock as being nought but a fallen angel from the world of astronomy! What, however, of the state of things before de Dondi? His clock contains the very remarkable device of the escapement and all the wheelwork and weight-drive that is basic to the original invention. Where did these inventions come from? Something so sophisticated as the escapement could not have come into being suddenly except by a stroke of genius, and in such a case we might reasonably expect that some hint of the invention should have been preserved. We are, however, completely ignorant



)e Dondi's great clock, an astronomical machine of 1364, ›resents a puzzle. The earliest known mechanical clock, it is clearly too complex to have been an original invention. Gear train for a perpetual calendar, *above*, was one portion.

f a beginning. All that de Dondi tells us is that the escape- ıent is a common device in his time.

To inject some unity into the story, I therefore attempted to disentangle the clock from the history of me measurement and connect it, instead, with the longer nd earlier history of astronomical models, such as the strolabe and equatorium. This seemed just the attitude ıat was needed. It so happens that all the available exnples of geared, clockwork-like, fine mechanical devices efore the advent of the clock were models of this sort; e call them "protoclocks." There were several useful amples, preserved in museums or mentioned in texts, at connected well with this development; they were ared astrolabes and mechanical calculators for the planery motions, and seemed to have a continuous history. This led to the tentative hypothesis that the early perction of astronomical theory had induced men to make vine machines to duplicate the heavenly motions. These otoclocks were necessarily as complex as the astroımical theory, and their execution called forth a great al of fine mechanical skill of a sort not expended elseıere in early times. Such models acted as a medium for e transmission of high skills among scientific artisans rough the ages, which reached a pinnacle in the late iddle Ages and Renaissance and provided a reservoir of chanical ability that must be regarded as the source of r later scientific instrumentation.

There were still many problems to solve. Perhaps the eatest was that of the mysterious origin of the clock apement, one of the few major inventions that remained mpletely anonymous and unaccounted for. While worry- about this, I called one day at the Cambridge office of seph Needham, famous for his monolithic work on *ience and Civilization in China.* My purpose was to seek latest information on a well-known mechanical equatom, a planetarium-like object that had been constructed Su Sung in A.D. 1088, at the height of the Sung Dynasty China. In a sense, it is "well-known" because Su Sung's book, first written in 1092, has been several times reprinted and republished—most recently in 1922—and has often been quoted and cited in histories. But those who had written about it, and presumably all those who had looked at the many editions, had apparently never bothered to read the really technical material in it or to examine critically the numerous diagrams showing these mechanical details.

Quite apart from sundry astronomical peculiarities and the fact that the prime mover looked like a large water wheel, there was an arrangement of rods and pivoted bars and levers that seemed from the picture to act as an escapement, checking the motions of the wheels. Now, this object was securely dated some three centuries earlier than the first European mention of the escapement, and Needham needed little urging to translate pieces of the text and confirm that the mechanism was indeed an escapement.

From then on we worked day and night for some four months, with Needham and his assistant, Wang Ling, translating texts and providing the rapidly increasing historical background, so that together we could understand the mechanical details and fit this object into the known history of scientific technology. Because of the early invention of printing in China, and the Chinese custom of producing in each dynasty a sort of analogue to *Great Books of the Western World*, so that little of vital importance was lost, we have amazingly fine documentation for Su Sung and his machine. The information is perhaps more complete in some details than the facts we have about many nineteenth- and twentieth-century inventions.

Thanks to the comprehensiveness of Su Sung's book and the accompanying sources, we were able to work out an exact understanding—almost a modern engineering specification—for his machine. In the course of this we acquired so much new understanding of the terms that we were able to seek other, more fragmentary, texts and glean from them a previously unintelligible but now usefully complete story of how Su Sung was only the end of a long

Professor of the History of Science at Yale, DR. PRICE has long been interested in the development of clocks and astronomical calculating machines. This article, excerpted from his current book, *Science Since Babylon*, is printed with permission of the publishers, Yale University Press.

line of similar people who had built similar devices from the Han Dynasty (approximately Roman times) onward.

Su Sung's great device may be called an astronomical clocktower. It stood some thirty feet high, with another ten feet of observing instruments mounted on a platform on top. Concealed within the housing was a giant water wheel fed by a carefully controlled flow that dripped at a steady rate, filling the buckets of the wheel slowly. Each quarter-hour the wheel became so loaded that it tripped its escapement mechanism, and the whole tower burst into cacophonous activity with a great creaking and groaning of wheels and levers. On the tower top, the observing instrument was turned automatically to keep pointed steadily at the moving heavens. In a chamber below, a marked star-globe also rotated automatically to provide a microcosm on which the astronomer could see the risings and settings of stars and planets without going outside; it is said proudly of this globe that "it agreed with the heavens like two halves of a tally." On the front of the clocktower was a miniature pagoda with a series of doors one above the other. At appointed times, whenever the escapement tripped, these doors would open and little manikins would appear holding tablets marked with the hours of the day and night, ringing little bells, clashing cymbals, and sounding gongs. It must have been a most spectacular sideshow.

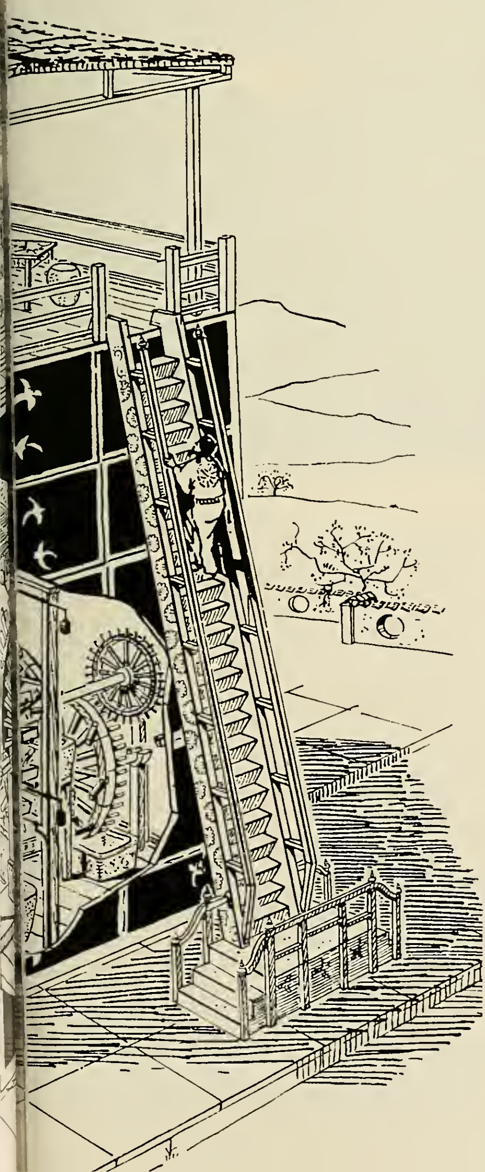
FOR all the complexity of its externals, the Su Sung clocktower was a comparatively simple mechanism. The big water wheel needed only a simple pair of gears to connect it to the rest of the paraphernalia, which in turn needed only the most elementary mechanical levers and such devices to produce its effects. Only the escapement mechanism was totally unexpected and refined. It did not tick backward and forward quickly, as in the mechanical clock, controlling all the timekeeping properties. Neither was it like the European water clocks, in which a continuous stream of water produced continuous or intermittent action, depending solely on the rate of drip of the water. Su Sung's was definitely an intermediate and missing link in the development of escapements. We managed to trace the invention of this form of water-and-lever escapement back to one of the many earlier astronomical clocks built in A.D. 725 by the Tantric monk I-Hsing and his engineering collaborator Liang Ling-tsan. We also succeeded in tracing the line back to the first-known clock in the series, which had been built (perhaps as a non-timekeeping astronomical model) by Chang Hêng, about A.D. 120-140.

What was perhaps more important was that we were able to suggest, at least, how this Chinese invention might have been transmitted to Europe. Curiously enough, one of the other workers on clocks, contemporary with Su Sung, was Shen Kua, who is deeply involved with the history of the magnetic compass. This device seems to have become known in Europe at much the same time as the escapement, which, of course, had also been transmitted from the Far East instead of having been a home product, as we had previously supposed.

In the context of the larger history of civilizations, it is of the greatest interest that heavenly clockwork develope[d] not only in the West but also in China, where mathematica[l] astronomy was much weaker and not nearly so compli-cated. The reason is, of course, that even something s[o] basic and mathematically simple as the daily cycle of rota-tion of sun and stars, and the yearly cycle of the sun an[d] calendar, was so fascinating that it must have been almos[t] irresistible for some men to play god and make their ow[n] little universe. It bears emphasizing that since the existenc[e] of such clockwork is the most sensitive barometer we hav[e] for the strength of the high scientific technology in [a] society, we must say that at this period in the Sung, th[e]

Chinese had reached a remarkable level in the ratio of high technology to pure science. In East and West, the echnology must have been at much the same level, insofar ıs one can compare them at all. In the East, pure science vas not inconsiderable; the Chinese had done many things ıot yet achieved at that time in Europe. The West, on the ›ther hand, had the glory of high-powered, mathematical ıstronomy that eventually dominated our scientific destiny.

The more recent events in the chronological development vere beginning to fall into a pattern. It provided a whole ange of clockwork *before* the clock, included a reasonable uggestion for the origin of the escapement, and united the previously separate provinces of water clocks, mechanical clocks, and astronomical protoclocks. One might add that there resulted even more security in the supposition that this was no mere piece of antiquarian parochialism within a province of the history of technology of science. Rather, it was an essential key that would lead ultimately from some beginning to an understanding of the whole world of fine mechanics and complicated machines that grew up during the scientific and industrial revolutions.



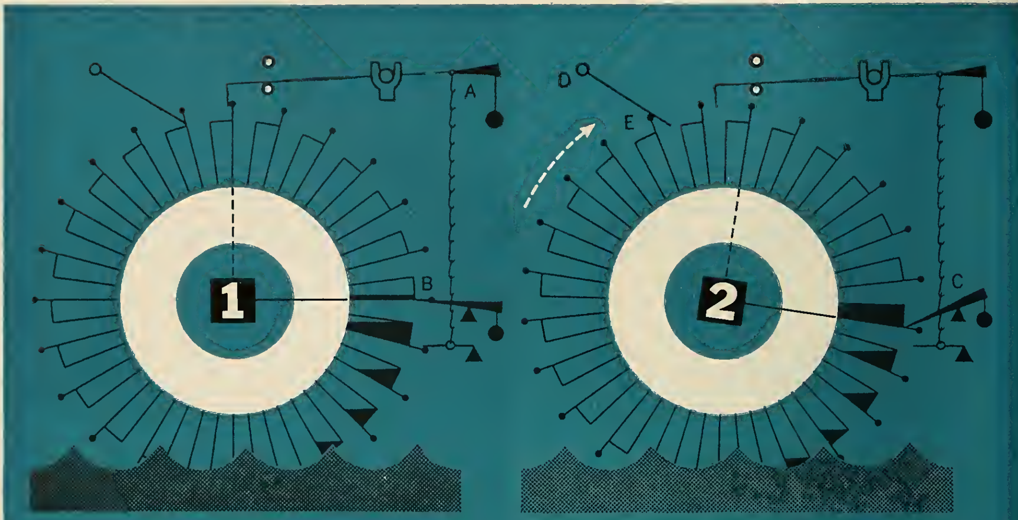
At this point, taking stock of the situation, I began to feel much more puzzled about the historical origins of the whole process at the early end of the time scale. Although I felt sure in my bones that the initial motivation for divine astronomical models must have come from the complex Greco-Babylonian astronomy in Hellenistic times, there seemed little to support the conjecture. The astrolabe, it is true, was mentioned by Ptolemy and might well have been invented, in principle at least, by Hipparchus in the second century B.C. This is, however, a mechanically very simple device, although mathematically most ingenious. It consists merely of a special, circular star map that may be suitably revolved to show where the stars are at any time of any night of the year. It is still used in modified form (as a "star-finder") by Boy Scouts and others, although the old brass astrolabe with its mathematical elegance of stereographic projection is an infinitely more delectable instrument than is the commonplace cardboard starfinder of today.

What was needed as supporting data was some highly complex mechanical device from antiquity, preferably full of gear wheels and obviously constituting a precursor of the clock. But when one examines Greek mechanical devices critically in a hunt for clockwork, all the ingenuity and appearance of complexity seem to evaporate. Almost our only sources for description of machinery are the writings of Archimedes, Heron of Alexandria, and Vitruvius. All these writers mention the use of geared wheels in some form or other, and the use of geared wheels must have risen quite early, perhaps around Archimedes' time.

For all the evidence of the use of gear wheels in simple pairs, there appeared not a single example of anything that we would regard as a complex machine. Perhaps the best is the odometer described by both Heron and Vitruvius, but this employed only pairs of gears in tandem to provide a very high ratio for speed reduction. It was a counter that indicated miles traveled by recording the number of revolutions made by a peg on the axle of a carriage or of a special paddle wheel hung over the side of a boat.

If this is the beginning of all clockwork, it is not very glorious, and frankly I hoped for something better, although at my ears was the solemn judgment of the classicists that the Greeks were not interested in these degrading mechanic occupations. There are good authorities for this attitude, and it may be a reasonable consequence of the existence of slavery, as has often been noted. Thus, the Greeks appeared to be interested in mechanics only for what mental gymnastics it could afford and preferred to pass silently over as much as possible of the low, everyday technology. There was ground for hope, however,

SU SUNG'S CLOCKTOWER, built in 1090, is another, earlier, astronomical machine, which was run by water power. The reconstruction at left was prepared by John Christiansen.



Escapement drove the machinery of Su Sung's clock, turning the steady water flow into periodic activation of main drive-wheel. Here the drive-wheel is at rest, held in position by the upper balancing lever (A), while the water scoop (B) on edge of the drive-wheel is filled from a reservoir (not shown).

Wheel moves when a scoop is full and weight of water overrides counterweight of the lower balancing lever (C). As drive-wheel starts to turn, a ratchet (D), which prevents recoil at a later phase, is lifted by the advancing scoop-pin (E), behind which it will drop into a new position and be locked in place

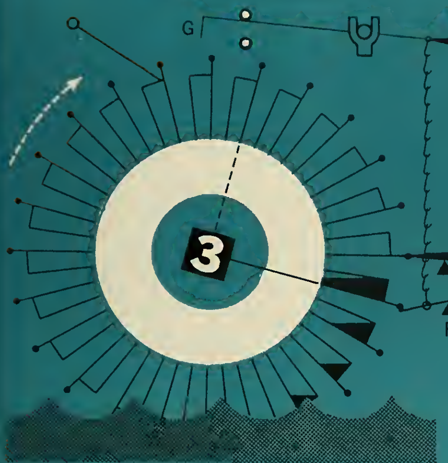
because Heron of Alexandria shows in his book on the *Automaton Theater* and in his *Hydrostatics* a certain schoolboy delight in ingenious trick devices. Although none of these devices uses anything mechanically more advanced than simple levers, strings, and, in a few odd instances, gears, here was the right attitude. This, however, in such weak form, could not be all there was to show for the great days of Greece.

At this point, the winds of chance blew me to haven at the Institute for Advanced Study at Princeton in the company of a number of fine classicists, epigraphers, and archeologists, as well as physicists and other scientists. In this assemblage it seemed to be natural to bring out of cold storage the one piece of material evidence in the field. It had been considered exciting by all researchers, but had hitherto been rejected by all because of difficulties so overpowering that it seemed hopeless to consider it anything but an oddity that we might some day approach when further material came to light.

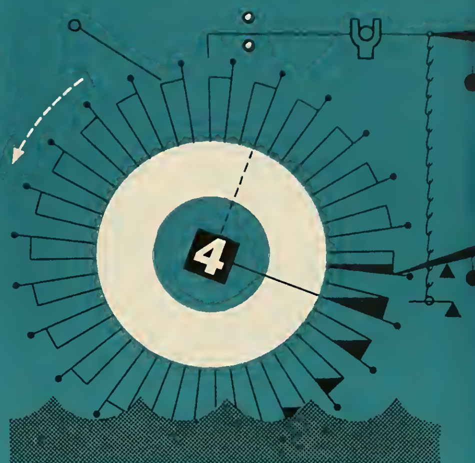
This evidence was an object brought to the surface in the first and unexpected discovery in underwater archeology, in 1900. During that year, Greek sponge divers, driven by storm to anchor near the tiny island of Antikythera, below Kythera in the south of the Peloponnesus, came upon the wreck of a treasure ship. Later research has shown that the ship, loaded with bronze and marble statues and other art objects, must have been wrecked about 65 B.C. (plus or minus ten years), while making a journey from the neighborhood of Rhodes and Cos and on its way, presumably, to Rome.

Among the surviving art objects and the lumps of corroded bronze and pock-marked marble, there was one pitiably formless lump not noticed particularly when it was first hauled from the sea. Some time later, while drying out, it split into pieces, and the archeologists on the job immediately recognized it as being of the greatest importance. Within the lump were the remains of bronze plates to which adhered the remnants of many complicated gear wheels and engraved scales. Some of the plates were marked with barely recognizable inscriptions, written in Greek characters of the first century B.C., and just enough could be made of the sense to tell that the subject matter was undoubtedly astronomical.

Unfortunately, the effect of two thousand years of underwater decomposition was so great that debris from the corroded exterior hid nearly all of the internal detail of inscription and mechanical construction. In the absence of vital evidence, the available information was published only rather uncertain and tentative speculation was possible about the nature of the device. In the main, the experts agreed that we had here an important relic of a complex geared astronomical machine, but opinions differed about its analysis and any relation it might have to the astrolabe or to a sort of planetarium that Archimedes is said to have made. Several efforts were made by scholars during the



FORWARD MOVEMENT of wheel now brings pin of the filled scoop in contact with the trip lever (F), and weight of the water is sufficient to drag down both trip lever and the chain that suspends it. Motion of chain, in turn, raises the upper stop (G), making it possible for the advancing scoop-pin to go by.



WHEEL STOPS as the lower scoop-pin passes the trip lever. The chain rises again, and balancing lever then locks the next water scoop in place. Ratchet at top of the wheel prevents any recoil and the next scoop starts to fill. It took nine hours for all the scoops on the drive-wheel to fill up and pass by.

st half of this century, but the matter remained inconusive, and had to stay that way until the painstakingly ow labors of museum technicians had cleaned away ough debris from the bronze so that more inscription uld be seen and more gear wheels measured.

With my new interest in astronomical machinery, and e facilities and help of the Institute at my disposal, I refully re-examined a set of new photographs of the agments, which had kindly been provided for me a few ars before by the Director of the National Archeological useum at Athens. Although a considerable cleaning of e fragments had made both lettering and gearwork much earer than before, they were not clear enough to make possible to solve the three-dimensional puzzle of fitting agments together by relying on the photographs alone. A grant from the American Philosophical Society alwed me to visit Athens that summer. Through fortunate cumstances, the assistance was available there of George amires, an epigrapher friend from the Institute, who lped me by masterly readings of the difficult inscripns. The museum authorities were most co-operative, d it proved a none too arduous task to sketch the details the mechanism, measure everything that could be meased, and photograph every little fragment. So armed, I turned to Princeton and to the jigsaw puzzle.

Little by little, the pieces fitted together until there relted a fair idea of the nature and purpose of the machine d of the main character of the inscriptions with which it was covered. The original Antikythera mechanism must have borne a remarkable resemblance to a good modern mechanical clock. It consisted of a wooden frame that supported metal plates, front and back, each plate having quite complicated dials with pointers moving around them. The whole device was about as large as a thick folio encyclopedia volume. Inside the box formed by frame and plates was a mechanism of gear wheels, some twenty of them at least, arranged in a non-obvious way and including differential gears and a crown wheel, the whole lot being mounted on an internal bronze plate. A shaft ran into the box from the side and, when this was turned, all the pointers moved over their dials at various speeds. The dial plates were protected by bronze doors hinged to them, and dials and doors carried the long inscriptions that described how to operate the machine (illustration, p. 17).

IT appears that this was, indeed, a computing machine that could work out and exhibit the motions of the sun and moon and probably also the planets. Exactly how it did this is not clear, but the evidence thus far suggests that it was quite different from all other planetary models. It was not like the more familiar planetarium or orrery, which shows the planets moving at their various speeds, but much more like a mechanization of the purely arithmetical Babylonian methods. One just read the dials in accordance with the instructions, and legends on the dials indicated which phenomena would occur at any given time.

umbers of Experimental Toads (fed intact, ve Honeybees) and Control Toads (fed dead oneybees, with stinging apparatus removed) ating and rejecting a final Dronefly Mimic.

	Experimental Toads	Control Toads	Total
te nal imic	9 [illegible]	19 [illegible]	28
ejected nal imic	13 [illegible]	3 [illegible]	16
otals	22 [illegible]	22 100%	44

like the other two controls, it ate all the dragonflies. To summarize, then, of the fifty-one robberflies presented to the control toads, thirty-four (67 per cent) were eaten.

One further aspect of mimicry remained to be tested. Was the sting really the source of the bumblebee's noxiousness? It is quite easy—with the aid of a dissecting microscope and fine watchmaker's forceps—to remove a bee's stinging mechanism. First the bee is anesthetized with carbon dioxide. Then it is placed on its back on the stage of the microscope. The abdomen is pressed carefully with the forefinger, which causes the sharp point of the stinger to protrude. This is grasped with the forceps, and the whole stinging apparatus and the sac containing the liquid poison is pulled out. Thirty-six bumblebees were prepared in this way and were then presented to the three control toads. Twenty-four of the harmless bumblebees were eaten by the two toads that had eaten robberflies. The third toad, which had been bumped by the robberfly, rejected the twelve operated bumblebees presented to it. These results told us two things: first, that the sting was the source of noxiousness in bumblebees, and second, that a toad that refused robberflies would also reject bumblebees. This indicated that toads fail to distinguish between bumblebee models and robberfly mimics.

If we now look at the results of this experiment as a whole, we can reach several conclusions that answer the initial questions we set out to test. The experimental toads showed us that live bumblebees were highly noxious to them and that toads, after being stung, could learn to reject bumblebees on sight. When the robberfly mimic was offered instead of a bee, the toads also refused the mimic. However, two control toads that never experienced bumblebees ate robberflies readily. Therefore, we concluded that the rejection of the robberfly by the experimental toads could be attributed to mimicry. These toads apparently learned that the bumblebee's color pattern was associated with the noxious sting and confused the robberfly's coloration with that of the bumblebee. Mimicry was thus shown to be effective.

A second experiment was performed with honeybee models and their dronefly mimics. A large number of toads served as caged predators. We wanted to be able to compare the reactions of toads that ate mimics freely at the beginning of the experiment with the same toads' reactions to mimics after experiencing the model.

Next presentation of a bumblebee to toad evokes negative reaction in form of ducking and rejection. This showed that toad had learned bee was noxious.

In order to do this, it was necessary for each toad to pass a qualification test before being allowed to participate in the experiment; each had to begin by eating mimics as well as the edible mealworms. Of the sixty-seven toads that were brought in from the wild and tested, forty-four qualified. The other twenty-three did not, because they failed to eat mealworms or droneflies, or both. Fourteen of this group ate their mealworms but refused the first dronefly, and some also exhibited a reaction of rejection to the droneflies by ducking and puffing up. Without further experiments it is not possible to say conclusively why the toads rejected the initial mimics. However, their behavior suggested strongly that these animals were already agents in mimicry: that the toads had had experience with honeybees before being caught, and when they were confronted with mimics in the laboratory, they confused the two. This is possibly a valid conclusion, because all fourteen of the toads ate the mealworms, which shows that they were discriminating between the food items offered, and were not simply rejecting everything.

In addition to the qualification test to select only those toads that would initially eat the mimics, a second precaution was taken to insure that only visual mimicry was involved in the investigation. All the droneflies were killed by deep-freezing before they were presented to the toads. In this way, we eliminated the possibility that auditory mimicry, caused by the similarity of the buzz of the dronefly mimic and the honeybee model, might influence the toads' reactions. To begin the experiment, the forty-four qualified toads were divided into two groups: half were designated as experimental subjects, and the others as controls. The experimental animals were given a series of five live honeybees and five mealworms. The control toads were given five dead honeybees from which the stinging apparatus had been removed, and five mealworms. These bees had also been killed by deep-freezing to eliminate their buzzing, which in itself might have caused the controls to reject them. The order in which the insects were presented to all the toads in both groups and the reactions of a typical control toad and a typical experimental toad are shown in the table on page 14, *upper left*.

The experiments showed that the live honeybees did indeed sting the experimental toads, although apparently not as severely as the larger bumblebees had stung the toads in the other tests. A few of the toads ate the live honeybees without evident discomfort, but most, after receiving two or three stings, rejected the honeybees on sight. The control toads, for the most part, readily ate their frozen bees from which the stinging mechanism had been removed. This shows that the sting of the honeybee, perhaps reinforced by its buzzing, accounts for its rejection as food by the experimental toads. Both groups of toads continued to eat mealworms throughout the experiment. This indicates that the experimental toads that rejected the bees actually had learned to tell the difference between the two. In the final test, both the controls and the experimentals were given a last dronefly mimic, followed by a final mealworm. All forty-four toads ate the mealworm, which indicates that they accepted in-

Effective mimicry is demonstrated when the toad also rejects previously acceptable robberfly, which it seems to confuse with the stinging bumblebee.

LACK OF EXTERNAL EARS is one way in which true seals differ from sea lions and fur seals. This cow's teeth equip her admirably to defend her offspring.

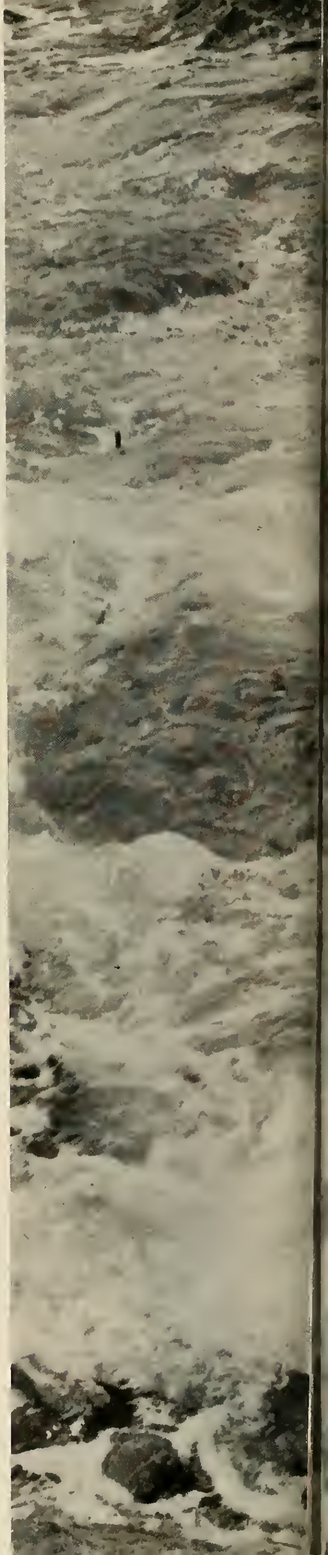
Tracking the Gray Seals

Fishery needs pose management problem

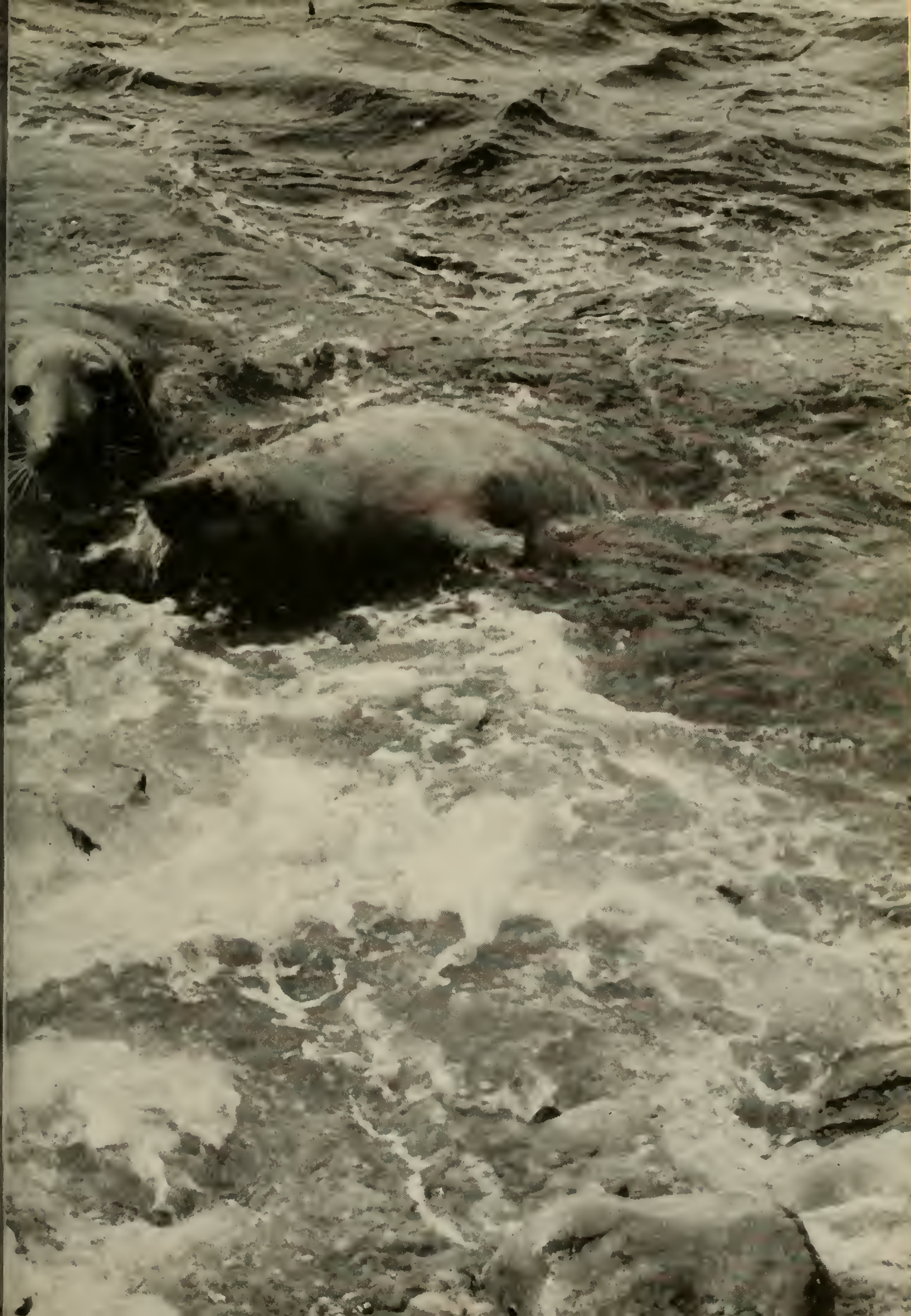
By E. A. SMITH

STUDIES OF THE GRAY SEALS that inhabit British waters have recently been intensified. This follows an increase in the volume of complaints made by inshore salmon fishermen that the animals are causing serious damage to their fishing gear and mutilating the catch. The netsmen assert that there has been a dramatic increase in the number of seals, and that the holes they tear in nets, and the fish they consume or release, in some cases result in crippling financial loss. A research program has been embarked upon by the Nature Conservancy, which aims to find out as much as possible about the habits and life-history of the seals, and to assess their actual effect upon fisheries. When sufficient information has been obtained, it may be possible to draw up a plan of management of gray seal stocks. This must be finely balanced to insure both the future of a valuable member of the British fauna—which is probably rare compared with many other seal species—and of the salmon fishing industry.

One factor that makes the seals important enough to be the subject of government-sponsored research has been their protection by law. In 1904, the gray seal was described as probably the least-known British mammal, although it had always been hunted for skins, for oil, and for sport. Suddenly, in 1914, one of the sportsmen, beginning to fear the extinction of the animal, caused sufficient agitation for Parliament to pass a law that forbade killing the animals in the breeding



COW STAYS TO SEAWARD while her pup ventures into water for the first time.



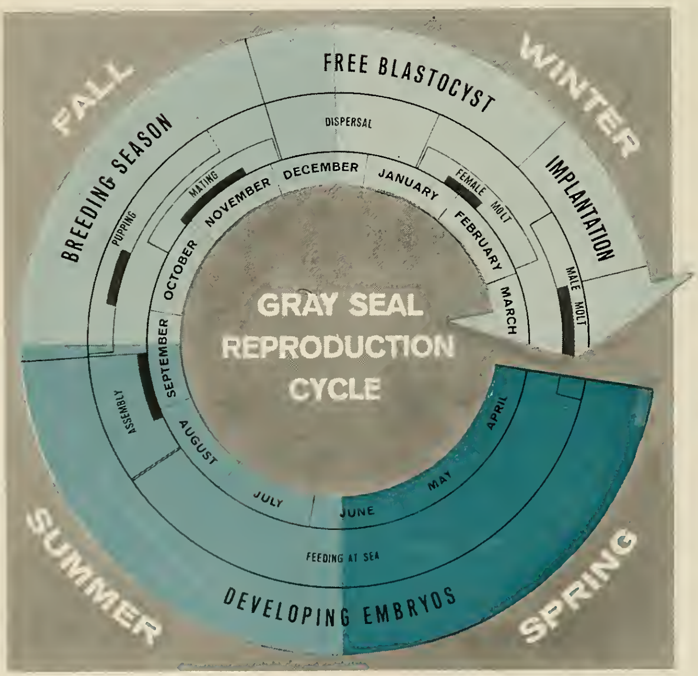
AT BIRTH, gray seal pup weighs only about 30 pounds and is some 30 inches long. Its pelt is dense, silky, and white.

AT THREE WEEKS, pup has become a rotund 100 pounds, and will fiercely resist any effort made to weigh, sex, or mark it.

season. It now seems certain, however, that the bill was based upon scanty and inaccurate information. Estimates of 500 seals in British waters were quoted, and not until 1928 was a new count attempted. At that date the stocks were put at 4,000 to 5,000. Although this showed that gray seals were in no immediate danger of extermination, and that probably their breeding habits afforded considerable natural protection, a second Protection Act was passed in 1932. This stipulated a closed season of four months, beginning on the first of September, but gave powers to allow for its suspension by the Ministry of Agriculture and Fisheries if this should at any time be thought necessary.

The problem that faced the zoologists was far from being a straightforward ecological exercise. The history of the populations is shrouded in mystery, so that any proof or measurement of an increase in numbers is almost impossible. Furthermore, the gray seal chooses to come ashore to breed in the late fall and winter on the most inaccessible and stormbound of Britain's offshore islands. But it is only from direct studies of these breeding colonies that much of the data required for a life table, and for studying the range of movement of which the gray seal is capable, can be obtained. Through the generous assistance of the Royal Air Force, a series of low-level flights has been possible over the principal seal islands in Orkney, a group of 60 or so small islands to the northeast of Scotland. In September we have seen vast numbers of adult seals, sleek and fat after four or five months of feeding, hauled ashore on the more outlying islets. This assembly increases daily and is at its height at low water. Last year a detailed study of the seals' subsequent behavior was conducted.

In early October, the breeding caves, beaches, and grassy swards beyond are invaded by the seals. Generally, the bulls are the first to arrive to establish their territories. Their three-inch layer of blubber, thrown into folds round the neck, ripples the length of their glistening bodies as they lumber out over the rocks. They are dark brownish gray, nine feet long, and weigh up to 800 pounds. They need their reserves of fat, for they will not feed for the four to eight weeks they spend ashore. This is a period of territorial fighting and courtship, and each will mate with up to twelve cows. The cows, which follow the bulls, have a lighter pattern of marking, commonly with a striking black-and-white dappling on



DARK GRAY BANDS over months depict peak periods of the seasonal activities

the chest. They are slightly shorter than the bulls, are slimmer about the head and neck, and weigh up to 500 pounds. Their store of blubber allows them to produce a milk ten times richer in butterfat than a domestic cow's.

The more aggressive bulls take up favorable territorial positions along the beach or astride a gully or stream that leads inland. Some of the subordinate bulls that arrive later have territories either on smaller beaches, in caves, or inland—sometimes several hundred yards from the sea. As the cows come ashore, those in the territories of the bulls farthest from the sea pass among those of the prime bulls on the way. The pups, which were conceived the previous season, are born about two days later. The birth of the single pup is extremely rapid, as in all seals, following a few massive muscular contractions, and generally but a single grunt. For a while, the mother ignores her offspring more or less completely; there is no cleaning of the pup nor eating of the placenta. After about half an hour and a few preparatory sniffs, she rolls on to her side to expose the two abdominal teats, which are stimulated to evert by the gentle pummeling of the pup's snout. At birth, the pup is a skinny 30 inches long, weighing about 30 pounds. It is born with a dense, silky, white pelt, which at first is stained with amniotic fluid. In a few days, it becomes cleansed by sea spray or rain. At first, suckling occurs every two hours or so, gradually becoming less frequent and finally ending when the pup is about three weeks old and has reached a rotund 100 pounds. Although most photogenic at this stage, the pups snap furiously when they are handled for weighing, sexing, and marking purposes.

When the pup is between three and four weeks old, its white coat molts, leaving a shorter, silvery-blue second coat. Soon afterward the pup, which has already taken preliminary dips with the mother, finally swims away from the island. Its blubber reserves support it for several months, during which it gradually learns to feed—first on crustacea and mollusks, and later on fish. A yearling seal weighs scarcely more than one that is only four weeks old.

Meanwhile, the cows, which for a fortnight have repulsed any approach made by the bulls, begin to allow courtship advances. The mating that follows usually takes place on land, but occasionally in shallow water; copula-

Grass and rushes are flattened at center of colony where watchful cow suckles her two-week-old pup. White coat will molt in a few more weeks, leaving a shorter, silvery-blue second coat that later will change again into adult pelage.

LUSH GRASS at island's center, as far as a quarter of a mile from the sea, is birthplace of this pup. Its mother in territory of one of less aggressiv

ɔr otherwise subordinate bulls that was
forced from favored spot at ocean edge.

Dr. Smith, who received his degree in ecology from London University, has been with the Nature Conservancy for two years, following two years' work in pathology at the London Zoo and three years as a R.A.F. officer.

tion is passive and generally lasts about half an hour. Breeding activity reaches its peak in late October and falls off completely by early December. Adults then leave the breeding islands, shadows of their September selves.

When pupping begins, the research parties move onto the seal breeding grounds, usually to live in a tent equipped with bare essentials and a radio transmitter. The scientific program is based upon the regular censusing of the island pups. With practice, and because growth and molt during the first weeks are so rapid, all pups can be divided on sight into weekly age groups. Where practicable, all pups present at the first census are dye-marked so that, on the next census, the unmarked—and thus newborn—pups can be identified. The sex and condition of each pup is noted. From figures collected in this way, the mean daily birth rate can be calculated. On the single island of North Rona, which is northwest of Scotland, the highest rate is about 70 pups born each day, and the total yearly output is about 2,300. In Orkney, the total pup production of some 3,000 is spread over eight small islands, the most important of which is about one-half by one-third of a mile in area. In this small enclave roughly 1,000 pups are born each year.

With such numbers involved, several factors make it impossible to arrive at exact figures. The dye-marking is sometimes impracticable. About a quarter of the total number of cows will vigorously defend their pups against human intruders, and it is by no means prudent to risk a mauling when isolated on such an island. Violent storms are frequent during the breeding period, and these can cause the death of scores of the pups born nearest the sea. In Orkney the seal islands are but a few miles apart, and movements of even the very young pups and their mothers from island to island can be recorded.

The mortality of the pups is studied—it amounts to 20 to 30 per cent on the most densely crowded beaches. The deaths seem usually to have been caused by starvation following the

Battles are not infrequent among the prime bulls as they attempt to maintain the territories they have established. During their eight weeks ashore every bull mates with up to twelve cows, and eats nothing during the entire period.

natural hazards that cause mothers to lose their pups, or through storms. Also, the most densely crowded islands rapidly become muddy wallows full of rotting placentae, excreta, and corpses. Thus, the many scratches and cuts that the rapidly developing and otherwise healthy pups frequently sustain often lead to a fatal septicemia.

The ratio of male to female pups is carefully recorded, and although there are periods when there is a distinct bias one way or the other, for the season as a whole the sexes are produced in equal numbers. Now that we have a reliable method of aging seals by tooth-sectioning, it is also possible to make studies of the ages and territorial structure of breeding adults. While enabling great strides to be made, these studies also tend to emphasize gaps of knowledge that we are trying to fill at present. First of all, the breeding cows are found to outnumber the territorial bulls by an average of about ten to one. What has happened to all the other bulls, since they are born in equal numbers? The question is further complicated: we find that the ages of the cows present (their expectation of life appears to be about thirty-five years) range from early maturity—at six or seven years—to over thirty. On the other hand, the bulls, which are potentially sexually mature at six or seven years, appear to have a life expectation of about twenty-five years. Yet over 90 per cent of those present on the breeding grounds are between ten and fifteen years old. In Orkney, we have recently been able to recognize mixed "haul-outs" of seals during the breeding season, and these are in places where there is no pupping. They include some immature cows and others that failed to become pregnant in the past year, but bulls of all ages predominate. These bulls include immature animals, those that are sexually mature but not socially dominant, and a number of older animals that have still to move onto the breeding beaches or that have left, driven from their territories by younger, stronger bulls.

Another factor that may account for the smaller number of bulls is that, during the breeding season, they may spend up to seven or eight weeks on shore. When they leave the beaches they are exhausted and thin, often with streaming wounds on their necks and flanks—a record of their territorial battles. It is thought likely that there is consequently a high mortality of bulls as compared with cows, which would account for the disparity in numbers.

Perhaps the most interesting gap in our knowledge, however, concerns the cows. Mating takes place between the erstwhile nursing cows and the territorial bulls on or near the breeding beaches. The mature cows wh

ᴺEWLY ARRIVED cow, *right,* awaits the ›irth of her pup at edge of mud wallow.

ıappen not to have born a pup in the ame year, together with a larger num- ›er of mature but virgin cows of five r six years old "haul out" away from he principal breeding beaches. Where o these animals become mated for the ollowing year? There must clearly be great deal of fringe activity, mostly n the water, of which, unfortunately, e know nothing as yet.

In common with many species of arnivore, the gray seal undergoes a eriod of delay after fertilization and efore the implantation of the blasto- yst and the beginning of the growth f the embryo. This delay lasts about wo months, after which the haul-outs f seals near the breeding grounds are een to be composed largely of cows. n late February and early March, the ows shed their roughened and faded oats to re-emerge in a beautiful dap- ling of black, white, and gray. There s clearly some endocrine complex ac- ıve at this time for, with the completion of the molt, implantation follows and the cows embark upon an eight-month period of gestation and feeding. The molt in bulls is somewhat later than it is in cows.

For about six months the seals are away feeding, and clearly their feeding habits are most important to the present studies. Unfortunately, they present the biggest problems, too. Opportunities for taking seals in order to examine stomach contents only arise when they are hauled out or are seen to be marauding salmon nets. In the former case, digestion is so rapid that the chances of obtaining recognizable material from the stomachs are small. In the latter case, if the seal drowns in a net, it invariably vomits; if it is shot, the stomach is likely to contain salmon —a fact that any fisherman could have told us anyway. However, evidence is being slowly collected showing that seals will eat almost any available fish, including commercially important species, and certainly they break into fixed nets to get at salmon and sea trout. To decide whether there is selective feeding on these species at sea will require a great deal more investigation. In winter and early spring, at least, there is a very high proportion of cephalopods in the diet.

The most striking feature of stomach analyses is perhaps the 100 per cent occurrence of large numbers of nematode worms. These are known to be adult stages of the codworm, although the intermediate, invertebrate host is not known. The seals, therefore, may have a positive economic effect on fisheries: the market value (and aesthetic appeal!) of cod flesh in which small pink worms are coiled is low.

As this is an investigation into the relation between seals and fisheries, it is important to attempt to relate the coastal regions where damage to fisheries is most acute to the colonies from which the seals come. Therefore, a system of marking individual seals is of utmost importance. Several types of tags on flippers or the tail have

When disturbed, adult seals hastily make for the water, pausing occasionally to cast wary eyes at the cause of their flight. Males are a dark, brownish gray, while the females can be distinguished by black-and-white markings on chest.

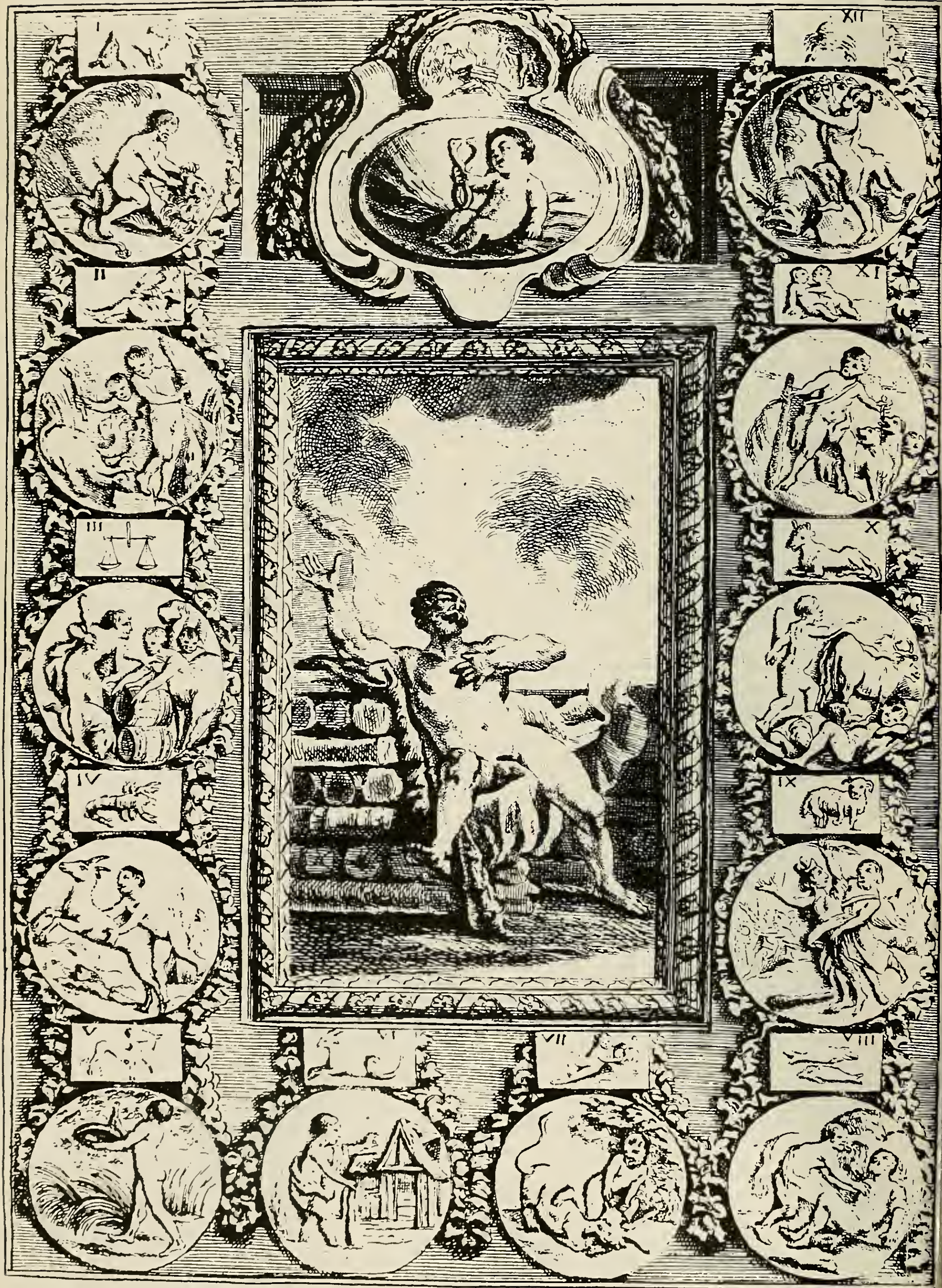
been tried with varying success, but very seldom has a tag lasted more than about a year and a half—unsatisfactory in an animal maturing at six or seven, and living twenty or thirty years. However, tagging has shed a great deal of light upon first-year movements. In 1960, for instance, in five of the main regions, 1,980 pups have been tagged and 160 recovered. These have shown that pups move as far as 600 miles—to Santander in Spain from Wales, to Iceland from Rona, or to Norway from Orkney and the Farne Islands. A more important, though less spectacular, pattern of movement of first-year animals in relation to salmon fisheries is emerging. It remains important to mark seals permanently so that studies can be made to ascertain movements of adults and whether they return to breed in their own places of birth.

Finally, it is very tempting to give estimates of British or world stocks of gray seals, or to postulate an increase in the numbers in the last half-decade. To do so with reasonable accuracy, however, demands that good censuses of pups are made in all the principal breeding regions, and that a factor obtained from a life table is used for estimating total populations of all age groups. As yet these data are by no means complete. All that can be said is that the species is in no apparent danger of extinction. It is probably more common than the Atlantic walrus and less common than the California sea lion. It exists in three main groups—in the vicinity of the Gulf of the St. Lawrence in Canada, in Iceland, Faeroes, Great Britain, west Norway, and in the Baltic. There appear to be minor differences in behavior and markings among the groups. Great Britain has about three-fifths of the world stock around her shores.

There are certainly more gray seals in Great Britain than was thought twenty years ago. But although there has probably been an actual increase in numbers, this increase may be somewhat obscured by an improvement in research techniques (in the use of airplanes, for example). It is known, too, that during the periods when Orkney and Farnes seals appeared to have increased in numbers, Norwegian stocks dwindled from many hundreds to a few score. This was caused by Norwegians hunting the seals to supply food for fox farms. Any apparent local increase must therefore be related to a possible redeployment within a larger area.

This brief outline of the Nature Conservancy gray seal research program has been written while preparations are being made for a further expedition to the breeding islands. It is possible that this season's studies may supply some of the missing data about the life cycles of these animals, their behavior patterns, and their ecology. It is to be expected, however, that as old questions are answered many new questions will present themselves.

Seaweed in rock pool fails to hide a five-week-old, newly molted pup that is here trying to evade the cameraman.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SKY REPORTER

Signs of the zodiac seem to be related to ancient solar myths

By Simone Daro Gossner

The origin of the zodiacal constellations is of the greatest antiquity and dates back at least to early Babylonian times. The zodiac, on the contrary, is a mathematical concept that is not found in any known text prior to about 400 B.C. By definition, the zodiac is a belt on the celestial sphere extending 8° on either side of the ecliptic, and divided arbitrarily into twelve sections (or signs), each with a length of exactly 30°. Starting at the vernal equinox and progressing eastward, the twelve signs of the zodiac are: Aries (the Ram), Taurus (the Bull), Gemini (the Twins), Cancer (the Crab), Leo (the Lion), Virgo (the Virgin), Libra (the Scales), Scorpio (the Scorpion), Sagittarius (the Archer), Capricornus (the Goat), Aquarius (the Water-Bearer), and Pisces (the Fishes). These signs have names that are derived from the constellations that span the sky within the zodiac.

The zodiacal constellations themselves, although they follow the same order, do not all have the same extent. Therefore, they could never coincide exactly with the signs. In fact, the constellation Libra was originally an extension of Scorpio called Chelae (the Claws). Furthermore, the gradual displacement of the north celestial pole causes a corresponding displacement of the vernal equinox westward along the ecliptic (see Natural History, January, 1962) with the result that the zodiacal constellations shift continuously with respect to the zodiacal signs.

The mathematical purpose of the zodiac was to provide a convenient frame of reference to designate the position of the sun, moon, and planets. The ecliptic, which bisects it, represents the apparent annual motion of the sun; the moon and planets never stray more than a few degrees from the ecliptic and remain almost always within the zodiacal belt. For this reason, the ancient astronomers found it convenient to express planetary positions in terms of a planet's distance—counted along the ecliptic—from the beginning of the zodiacal sign in which it happened to be located. Thus, for example, the position of Jupiter was said to be "Gemini 9°" when that planet had penetrated 9° inside the sign of Gemini. This practice has been abandoned, and modern astronomers prefer to count ecliptic longitudes from the vernal equinox. Since each sign spans 30°, one finds that Gemini 9° corresponds to ecliptic longitude 69°.

In ancient astronomy the zodiac was used only in mathematical computations that related to the preparation of ephemerides, tables of predicted positions. In actual observations, these positions were measured with respect to bright stars simply because the subdivisions of the zodiac have no visible counterpart in the sky. To this day, for example, the position of the vernal equinox, or First of Aries, can be determined only by indirect means. There is no practical use for the signs of the zodiac in modern astronomy.

Labors of Hercules are correlated with the twelve signs of the zodiac in an eighteenth-century French etching. It is doubtful that a close correspondence ever actually existed between the constellations' names and the Hercules myth.

In ancient lore, zodiacal constellations appear to have been related to several solar myths. The yearly course of the sun played an important role in the life of primitive communities. Its progress along the ecliptic was likened to a life cycle: youth and vigor were associated with spring, maturity with summer, decline with autumn, and death with winter. In early Greek communities the king was sacrificed every year at the winter solstice in a ritual that was undoubtedly related to this cycle.

The mythological hero Hercules, in particular, was one of the solar symbols. His familiar attributes—the club and the lion's skin—occasionally appear in ancient ornaments and temple decorations depicting a personified Sun. There is every reason to believe that the twelve labors of Hercules are equally symbolic of the sun's "struggle" along the twelve zodiacal constellations. The handsome etching on the facing page is an eighteenth-century French attempt to correlate each of the labors with its zodiacal counterpart. Such a task is hopeless, unfortunately, because the names of the constellations and the myth of Hercules have come to us through two separate oral traditions and, therefore, are bound to have undergone many alterations; besides, it is quite doubtful that there was ever a particularly close correspondence between the two.

One of the astronomical phenomena within the zodiacal region is the faint glow called the zodiacal light. Its appearance is caused by the presence in the solar system of countless tiny particles not much larger than grains of sand. Each of these particles behaves very much like a planet: each one travels in an orbit around the sun, remains close to the ecliptic, and reflects sunlight. Of course, the particles are too small to be seen individually, but their combined brightness, when viewed under optimum conditions, is comparable to that of the Milky Way.

A clear black night and an observation site as far as possible from the haze that hovers over cities are essential to viewing the zodiacal light. Shortly after evening twilight, it appears as a pyramidal glow. It is broader near the horizon, where it may be as much as 20° wide, and it tapers to a point as it stretches along the zodiac. The extent to which zodiacal light may be traced depends on observing conditions and on the acuity of the observer's vision. The light follows the diurnal motion of the stars and sets gradually at the rate of 15° per hour. A similar display occurs in reverse order before morning twilight.

At intermediate latitudes, such as throughout most of the United States, zodiacal light is seen best when the zodiac is nearly perpendicular to the horizon. This condition is fulfilled following evening twilight near the spring equinox (March and April) and in the early morning hours near the autumnal equinox (September and October). In the Tropics the ecliptic is nearly vertical at all times and the zodiacal light may be observed throughout the year.

THE SKY IN MARCH

From the Almanac:

New Moon	March 6. 5:31 A.M., EST
First Quarter	March 12. 11:39 P.M., EST
Full Moon	March 21. 2:56 A.M., EST
Last Quarter	March 28. 11:11 P.M.. EST

The sun will be at the vernal equinox, and spring will begin in the Northern Hemisphere, at 9:30 P.M., Eastern Standard Time, on March 20.

For the visual observer:

Mercury, at its greatest western elongation on March 3, will be observable in the early part of the month, although this elongation will not be a very favorable one. In the morning sky, the planet will rise an hour and a quarter before the sun on March 1, and 45 minutes before the sun on March 15. It will be too close to the sun for observation at the end of March. It will pass 1° south of Jupiter on March 13, and 1° south of Mars on March 18.

Venus, in the evening sky (—3.4 magnitude), will be poorly placed for viewing this month. It will set about 30 minutes after the sun on March 1, 45 minutes after the sun on March 15, and one hour after on March 31. By the end of the month, it may be possible to see the planet above the western horizon briefly before it sets.

Mars, in the morning sky (+1.4 magnitude), will be very difficult to see, except possibly for a few minutes each day in the latter part of March. It will rise 45 minutes before the sun on March 1 and 15, one hour before on March 31, and will be very low in the eastern sky at sunrise.

Jupiter (—1.6 magnitude) will be in the morning sky, rising 45 minutes before sunrise on March 1, one hour before on March 15, and an hour and a half before on March 31. The best time to look for Jupiter will be shortly before dawn in the latter part of the month.

Saturn, in Capricornus (+0.9 magnitude), will be visible during the entire month. Also in the morning sky, it will rise an hour and a half before the sun on March 1, two hours before on March 15, and two and a half hours before the sun rises on March 31. Saturn will be found low above the southeastern horizon at sunrise.

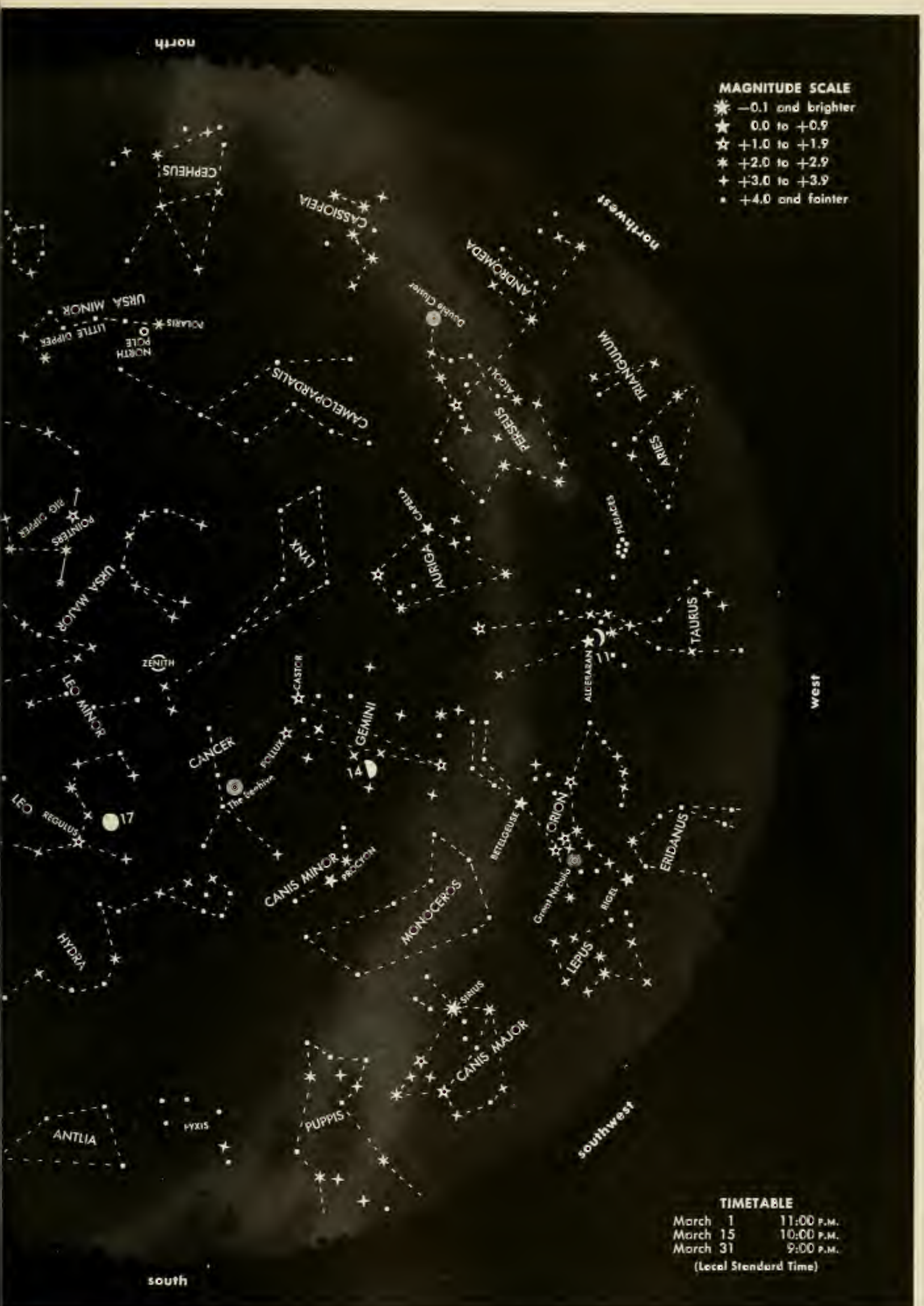
For binoculars and small telescopes:

The planet Uranus should be found without difficulty in the evening sky, less than a degree northwest of Regulus, in the constellation Leo. Although eleven days past opposition on March 1, it will be still essentially at its closest distance to the earth for the year (1,615 million miles), while its magnitude (+5.7) will be approximately at the limit of naked eye visibility.

Uranus was the first planet to be discovered telescopically (by William Herschel in 1781). By tradition the right to name it belonged to its discoverer and, in consequence, Herschel called it *The Georgian Planet* in honor of his patron, King George III. This choice was frankly repulsive to the newly independent United States, where the planet became commonly known as *Herschel*. Eventually the name *Uranus* was adopted because this seemed more in keeping with the other planets' names. However, the British Nautical Almanac continued to tabulate the positions of "The Georgian" for many years after the designation Uranus had gained general acceptance throughout the rest of the astronomical world.

On the preceding pages, MRS. GOSSNER offers the third in her 1962 series — a survey of the celestial sphere.

To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.



north
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
CEPHEUS
CASSIOPEIA
northwest
ANDROMEDA
URSA MINOR
LITTLE DIPPER
POLARIS
NORTH POLE
Double Cluster
TRIANGULUM
CAMELOPARDALIS
ALGOL
PERSEUS
ARIES
CAPELLA
PLEIADES
BIG DIPPER
POINTERS
LYNX
AURIGA
URSA MAJOR
TAURUS
ZENITH
ALDEBARAN
11
west
LEO MINOR
CASTOR
GEMINI
CANCER
POLLUX
14
The Beehive
ORION
LEO
REGULUS
17
BETELGEUSE
ERIDANUS
CANIS MINOR
PROCYON
MONOCEROS
Great Nebula
RIGEL
HYDRA
LEPUS
SIRIUS
CANIS MAJOR
ANTLIA
PYXIS
PUPPIS
southwest
TIMETABLE
March 1 11:00 P.M.
March 15 10:00 P.M.
March 31 9:00 P.M.
(Local Standard Time)
south

This is the 115th
of NATURE MAGAZINE's
special educational inserts

THE MUSTARD PLANTS

Staple foods and nuisance weeds can be found in crucifer family

By E. Laurence Palmer

The typical mustard flower is composed of a calyx of four equal sepals that are shed early; a corolla of four equal petals, so arranged as to resemble a cross; six stamens, of which two are much shorter than their companions; and a pistil that develops into a special sort of fruit known as a silique. The variations in this fruiting body form the basis for recognition of many of the "tribes" of family; important, too, are positions of the embryos in the seeds of various species.

The mustard plants commonly, if not universally, possess a strong and somewhat bitter taste that varies considerably with the treatment given the plant tissues. Water added to the crushed seeds induces changes with which many of the particular uses of mustards are identified. The concentration of significant properties in particular parts of mustard plants is common, but this is not a characteristic unique to the mustards.

As the chart accompanying this insert will show, pollination in the mustards is not uniform. Some plants require cross-pollination and develop in such a way that this method of reproduction is effected. Others are self-pollinating, and thus exhibit different structures and development patterns. Whatever the mode of pollination may be, there always seems to be an abundance of fertile seeds to start a new generation. The seeds are usually completely filled by the embryo, there being no free endosperm such as is found in many other types of seeds. The food for the next generation is commonly stored in the seed's two cotyledons, which usually constitute the major portion of the embryo.

The seed coats of the mustards vary considerably. Some are mucilaginous, and quickly take up available moisture at a time when prompt germination may spell success or failure. This sometimes makes it possible for mustard plants to begin growth sooner than neighboring plants, which are thus deprived of needed water; subsequent rapid growth also provides excessive shade that may be fatal to competing plants. The mucilaginous coats of some mustard seeds may play a part in their distribution. For example, if a weed top containing sticky seeds is brushed by an animal with wet hair or hide, the seeds may adhere to the animal, only to drop off later far from the site of the parent plant. Some mustard seeds are so small that they may be carried by the wind like dust, although they may lack the wings often characteristic of wind-disseminated seeds. Most mustard seeds are hardy when exposed to desiccation and extremes of temperature, and it has been shown that the seeds of ordinary shepherd's purse may remain buried in the soil for as long as twenty-five years, only to germinate promptly when suitable conditions occur.

Many of the most successful mustard species have seeds that mature at the same time as the seeds of commercially valuable crops. The mustard seeds are harvested with the crop seeds, unwittingly cared for by man, and then sowed in well-prepared soil to compete—often too successfully—with plants of the commercial crop. Fortunately, most mustard seeds are considerably smaller than those of many of the commercial plants, and can be sifted out with relative ease.

By any interpretation of the word "food," we find that the mustards are of considerable importance. This is true whether we view them as food for wildlife, forage for bees, food plants for man during emergencies, or cultivated as food both for men and beasts.

One important government publication, devoted to the wildlife uses of the mustards, lists a dozen birds and ten mammals that make substantial use of the plants as foods at various times. The list includes mule deer and white-tailed deer, antelope, cottontail rabbits, Townsend's ground squirrels, pocket mice, black-tailed and white-tailed prairie dogs, and three kinds of kangaroo rats. Probably this list does not include all the mammals that find sustenance in the mustards.

The same reference indicates that mustards in one form or another, provide food for Canada geese, ring-necked pheasants, mourning doves, both Grinnell's scaled quail and valley quail, and such songbirds as the rosy finch, house finch, Lawrence's goldfinch, California house finch, horned lark, and the pygmy nuthatch. Other writers have reported that ruffed grouse may feed on white mustard and peppergrass, and a few writers include some of the mustards among the food of ducks.

A year after some 50,000 Boy Scouts held a jamboree at Colorado Springs, Colorado, I visited their vacant campsite and was impressed by the dominance of peppergrass on the thoroughly trodden site. In the almost pure stands of these plants could be found the droppings of mice, rabbits, antelopes, and other mammals, showing that these creatures had been feeding on the plant, despite the fact that it has never been considered especially palatable even for such animals.

In his *Manual of Aquatic Plants,* N.C. Fassett comments on the importance of water cress—a crucifer—as a food for ducks, muskrats, deer, and smaller forms of animal life. He points out that this plant is often available in fresh form throughout the winter, when other plants are not. He refers particularly to the value of water cress as an indirect source of food for brook trout, which feed on fresh-water shrimps and water sow bugs that in turn prosper in tangles of water cress.

In his comprehensive book entitled *American Honey Plants,* Frank C. Pellett pays homage to the mustards as important sources of the nectar used by bees to produce honey. Pellett says that mustard honey is light in color and has a mild flavor, and that wherever mustard plants are abundant they can be expected to add substantially to the output of the apiary. He quotes another authority to the effect that mustard affords a larger amount of valuable pasturage to the acre for bees than almost any other plant. We also learn from Pellett, however, that mustard may attract bees away from fruit trees, presumably affecting the "set" of orchard fruits that depend upon bee activity to assure pollination. He cites the apple country of the Willamette Valley of northwestern Oregon as an example. Pellett suggests that, while white mustard is dependable as a source of commercial honey, black mustard may be fickle, sometimes forming the basis for tons of honey and at other times yielding only an abundance of pollen, which is a food for bees but not a honey source. He suggests that there are some fifty species of mustards, most of which are closely related to the cultivated cabbage, turnip, and

Peppergrass

Shepherd's purse

rutabaga, providing important bases for the production of honey, which is, of course, commercially valuable.

A considerable literature has been developed dealing with the uses of wild plants as food for man during emergencies that might limit the production of the more familiar commercial plant species. Included among these would surely be a few of the mustards, which have nutritive value, whatever their flavor. I have eaten some as relishes ever since the day my mother first showed them to me in my grandfather's woods. Knowledge of such survival plants can always be helpful.

Two excellent books on edible wild plants—one by Oliver P. Medsger and the other by M. L. Fernald and A. C. Kinsey—list and describe some thirty-six species of plants that are members of the Family Cruciferae. These include ten species of mustard of the genus *Brassica;* six species of peppergrass of the genus *Lepidium;* six species of crinkleroot of the genus *Dentaria;* three species of scurvy grass of the genus *Cochlearia;* and one species each of eleven other genera. Best-known of these are shepherd's purse, penny cress, sea rocket, water cress, winter cress and spring cress, some of which are figured and described in the accompanying chart section of this insert. Horseradish is also found in the list; its leaves are used by some people as greens, and its roots are popular as a fiery condiment.

The reputation of the crucifers as food plants for both man and beast center, for the most part, about members of the genus *Brassica.* Eleven of the eighteen species that were selected to represent the family in this educational insert belong to that genus. Four of the eleven are varieties of the species *Brassica oleracea,* including cabbage, kale, cauliflower, broccoli, and Brussels sprouts. The remaining seven species of *Brassica* that are of major food value are white mustard, field mustard, black mustard, rape, rutabaga, kohlrabi, and turnip. All of these will probably be familiar to the well informed, and they are illustrated and discussed in some detail in our chart section. Liberty Hyde Bailey's *Manual of Cultivated Plants* recognizes thirty-four species and varieties of *Brassica* that have been deemed of sufficient value to man to have been cultivated by him, presumably for food. There are undoubtedly many more valuable strains that have been developed to meet the specific needs of various soils, lengths of growing season, food value, market appeal, keeping quality, disease and insect resistance, and so forth.

It is difficult to fix a monetary value on the various agricultural crops. In a number of recent almanacs, some pages are devoted to the dollar values of agricultural products, and on none of these pages is the cash value of cruciferous crops estimated. It would seem to follow, therefore, that the Cruciferae are of minor importance as compared with wheat, cotton, oats, apples, flax, potatoes, tobacco, peas, sugar, peaches, citrus fruits, and even strawberries and cranberries. Nevertheless, a farmer who produces superior cabbages near a sauerkraut factory may be better rewarded in raising crucifers than in raising wheat.

Many of the crucifers are of considerable specific food value. The cabbage, for example, is rich in vitamins and sulphur. It is true that it contains about 91 per cent water; but it also contains sugar, starch, considerable protein, and valuable lime salts. (Sauerkraut is essentially silage for human use, and consists of cabbage fermented with salt in its own juices. Lactic acid bacteria acting on the sugar in the cabbage produce the acid that causes the sour taste.)

One must not overlook the role of the crucifers in providing forage for domestic animals. Properly managed, crucifer crops reduce the amount of human labor necessary in providing food for animals important to farm economy. Usually this means growing food at a time of year when other suitable foods are not available to pigs, sheep, and cattle. Some of the cultivated crucifers are well suited to this purpose.

As might be expected, the crucifers have entered both the folklore and the literature of the past. In 1597,


Radish


White mustard


Field mustard


Rutabaga

Dr. E. Laurence Palmer, for many years director of Nature Magazine's educational program, continues his special inserts in the pages of the combined magazines.

a British herbal written by John Gerarde quotes Pliny as saying that "whosoever taketh the seed of Rocket before he be whipt, shall be so hardened, that he shall easily indure the paines."

The physician Galen forbade the eating of lettuce without rocket, or of rocket without either purslane or lettuce. Another physician recommended the eating of rocket seed as a cure for the bites "of shrew-mice and other venomous beasts." In the eighteenth century a Mrs. Clements of Durham, England, is credited with inventing a method of making mustard flour similar to wheat flour, thereby realizing a fortune. For years, seafaring men made use of scurvy grass, a mustard, in the battle against scurvy. Interestingly enough, most of the early scurvy grass recipes advocated mixing the grass with citrus juices. The latter, of course, are now recognized as scurvy preventives by themselves.

We have dealt in part with the food value of the "cross-bearers"; it must also be recognized that some of these plants are considered poisonous. W. C. Muenscher's *Poisonous Plants of the United States* lists nine species of crucifers that at certain times and under certain conditions may be considered poisonous. Poisoning is usually the result of using the oils produced from mixing the ground seeds of the plants with water. Muenscher points out that apparently all of the plants in the group considered poisonous may be eaten in the young stages without danger, but that a precautionary measure is to treat the seeds with boiling water.

We have all heard of the use of mustard as a "mustard plaster" to generate heat and to produce a reputed healing action. Heat generation, as suggested in the chart section, is due to the action of water on the meal ground from mustard seeds.

One of the rather remarkable products of the seeds of some of our mustards is an oil that is used as a lubricant. The seeds of white mustard, when ground and treated with water, produce an oil used both in medicine and as a condiment; the same oil can be used as a lubricant or as an illuminant. The seeds of black mustard produce a similar oil, but one that is more virulent; it may produce a volatile sulphur that on direct contact can blister the skin and be dangerous to the eyes, nose, or the mucous membrane of the mouth. This oil is used in soapmaking, as a flavoring, and as a scent. Black mustard mixed with warm water is also used as an emetic. Ordinary, commercially ground mustard is usually a combination of meal made from the seeds of both black and white mustard.

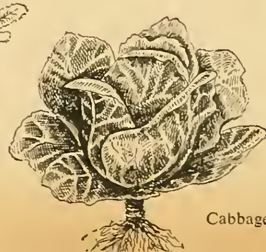
Summer school students are often enthusiastic about the countryside around my Cornell University home. They comment on the beauty of the fields of white, red, and yellow, not realizing, perhaps, that these colors are those of weeds, rather than of useful crops. The white is probably the bloom of the ox-eye daisy, which has little if any value, although the young leaves have a pleasant taste. The red-orange color is often Indian paintbrush, which has taken over a field too poor to support commercial crops. The yellow is almost certainly one of the mustards, which, like most of its relatives, is a successful opportunist, taking over territory not already occupied by other plants.

There are at least two admirable books on weeds. The *Manual of Weeds,* by A. E. Georgia, devotes twenty-four of its 558 pages to members of the Cruciferae, covering twenty-four species. W. C. Muenscher's *Weeds* devotes thirty-three pages to a consideration of thirty-six members of the Family Cruciferae, in a book slightly larger than the Georgia work. Since neither book includes any discussion of the economic crucifers, representatives of the genus *Brassica* are not as prominent as they are in the discussion on these pages.

Some people say that many plant species are considered weeds because they have seeds or fruits that are

Rape

Black mustard



Cabbage

Kale

provided with parachutes, permitting distribution by the wind. Mustards lack any such parachute devices, and yet their seeds are carried by the wind like fine sand. Some say that many plants are weeds because they are perennials, and once established, they remain. Most of our crucifers are relatively short-lived; or, at least, many of the weed crucifers live less than a year.

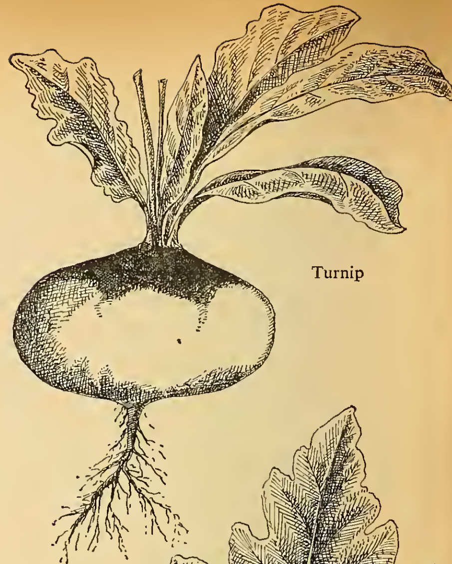
I once made a careful study of the seeds of plants commonly reported as impurities in commercial seed. Only twenty-five of the 356 species reported as seed impurities were members of the mustard family. This would suggest that in competition with members of other plant families the mustards are not highly successful. However, it is not the number of species that determines success, but the ability of plants to take over territory and to hold it. Mustards are able to spread quickly, but as a general rule they eventually are ousted by competitors. They are not usually able to establish the sods that are so effective in helping the grasses crowd out other plant species. Squirrels bury the nuts of nut-bearing trees, and do not ordinarily make caches of mustard seeds; yet when a walnut seedling becomes established, the chances are it will outlast its contemporary mustards. This brings us to the conclusion that the crucifers are successful weeds because they are among the "opportunists" of the plant world; they move in fast, produce an enormous number of hardy seeds, then allow competition to move in.

It is not surprising that plants that produce flowers as beautiful as those of most wild mustards should also be expected to produce some popular garden flowers. It might be apropos to list a few such crucifers, although this quality was not deemed to be of particular importance in selecting species for the chart section. Any good garden catalogue should offer a half-dozen kinds of candytuft listed under the genus *Iberis*. Moonwort of the genus *Lunaria* is often found in gardens, and is most attractive after the seeds have been shed, leaving only the partition that divided the fruit. This latter appears as a small, round moon.

If you do not think that crucifers are worth consideration as garden flowers, try to find a professionally planned flower garden without at least one border of sweet alyssum. Certainly a garden without a patch of rocket, *Hesperis,* would be most unusual. Rocket usually takes care of itself once it is established, and is often found around abandoned houses.

Stocks are mustards that often survive the critical judgment of the commercial florist, yet they also are to be found where the home gardener makes the decisions. Wallflowers of the genus *Cheiranthus* are relatively common in mixed borders. Their flowers are fragrant and richly velvety, in colors that range from cream to yellow, red, mahogany, plum, and bronze. Mixed with day lily, white stock, and campanula, wallflowers may make a satisfactory flower garden by themselves—one that may be maintained with relatively little effort on the part of the gardener. Wallflowers seem favored in western gardens for spring blooming in the coastal area known as the "fog belt"; but they are not limited in popularity to this particular region.

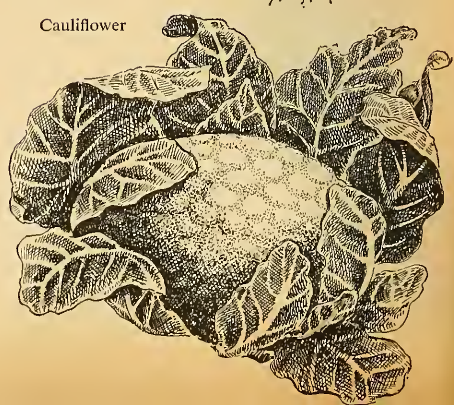
The crucifers are surely worth studying for their value to man, their beauty, and their versatility as food crop.



Turnip

Kohlrabi

Cauliflower



Horseradish

Tumbling mustard

Water cress

Winter cress

	DESCRIPTION	RANGE AND RELATIONSHIP
SHEPHERD'S PURSE *Capsella bursa pastoris*	Slender, tough stems, smooth or slightly hairy, to 2 feet in height. Basal leaves to 5 inches long, forming rosette; lance-shaped, toothed, or cleft. Small stem leaves without petioles, often with clasping bases. Roots have a deeply penetrating rootstalk.	Naturalized from Europe, now widely established throughout the world. Common weed in United States, found in lawns, gardens, roadsides, and wasteplaces—especially in soil that may be too poor to support other plant life. Highly variable in leaf form. As many as 63 forms have been recognized.
POOR-MAN'S-PEPPER, PEPPERGRASS *Lepidium virginicum*	Six to 15 inches high. Slender stems openly branched, with laterals long, slender, upward-curving. Basal leaves, tapering to form petioles, have a few small lateral divisions. Stem leaves small, lance-shaped, incised or entire. Flowers and fruits crowded on branches. Roots penetrating.	A common weed, native to American continent, naturalized in Europe and elsewhere. The species is found from Newfoundland to South Dakota, and south to Florida and Texas. Also in West Indies. Between 65 and 70 species, mostly annuals, have been differentiated; genus has wide distribution.
RADISH *Raphanus sativus*	Smooth, coarse, erect, many-branched stem, to 3 feet high. The basal leaves, usually with abundant stiff hairs, to 8 inches in length, with large terminal lobe and smaller lobes near base. Stout mature pedicels. Taproot is thin at top, then is greatly swollen, and finally becomes tough and slender.	Of doubtful origin, but introduced from Europe into New World; now widely established throughout world. Once prized by ancient Greeks and pharaohs, it is today a popular cultivated garden plant—and an unpopular escape. Not ruggedly persistent, yet is common in old fields and gardens.
WHITE MUSTARD *Brassica hirta*	Rather stout, sparsely hairy stem, 1 to 2 feet tall, although may even grow to 6 feet. Lower leaves to 8 inches in length, with large terminal lobe and usually paired lobes diminishing in size toward base. Upper leaves shorter, with margins less lobed and slightly toothed. Roots relatively deep.	Native of Europe and western Asia, but now widely spread throughout world by accidental or intentional introductions. Although essentially a temperate land plant, it is not common in Southern Hemisphere. Established in fields and waste places. Sometimes considered *Sinapis* species.
FIELD MUSTARD *Brassica kaber*	Stems to 3 feet high, with rather coarse, spreading branches. Plant bristles with stiff, slightly sticky hairs. Leaves are ovate in shape; the lower ones are sometimes slightly lobed, but more often toothed; upper leaves become progressively smaller, coarsely toothed. Leaves have short stems.	Naturalized from Eurasia, and now widely distributed as a common, conspicuous weed. Particularly coarse and vexatious, it is established in fields, gardens, and waste places. Closely related to other species, it is sometimes considered a *Sinapis* species.
BLACK MUSTARD *Brassica nigra*	Rather coarse stems, simple or branching, usually smooth above, with stiff hairs below. May grow to 5 feet high. Leaves petioled; lower are commonly lobed, with terminal lobe most conspicuous. Two to 4 smaller lateral lobes. Upper leaves toothed, with clasping petioles. Roots penetrating, not fleshy.	Naturalized from Eurasia, it is now cultivated extensively throughout Asian, European, and American continents. Has become established as a weed in fields and waste places, and it is generally cultivated for its value as the principal source of common table mustard.
RAPE, COLZA *Brassica napus*	Height to 4 feet, branching, with leaves to over 1 foot long and half as wide, nearly smooth, though sometimes with bristly hairs sparsely placed. Lower leaves lobed and contracted at base into winged petiole; bases of upper leaves clasp stem. Root slender, rather long. Stem somewhat purple at base.	Introduced from Eurasia, the annual type is grown for seed in Europe and Asia, while the biennial is commonly grown in America for forage and, in both Europe and America, for human consumption. Dwarf species most common. Persistent after cultivation, occurring as an escape in waste ground.
RUTABAGA *Brassica napobrassica*	Crown leaves are like those of rape; lower leaves are smaller. Leaves are smooth, with margins cut halfway to the midrib. It is much like a turnip, but with more elongated root, denser flesh, and with tubers tapering downward from lower half or third. Flesh is usually yellow, but sometimes white.	Commonly grown as a field crop in most temperate zones. Introduced from Europe. In Canada and England, known as "Swedish turnip" or "turnip-rooted cabbage." In northern United States, grown commonly as fall crop, but occasionally for spring pasturage. Is rarely long-persistent.
CABBAGE *Brassica oleracea* var. *capitata*	Head formed by inner leaves may be to over 1 foot across. Leaves are nearly circular and may also be to 1 foot in width. Outer leaves are coarse, green, and fairly flat; inner are paler, tender, and bunch to form compact head. Several head shapes, as well as color and seasonal differences, are recognized.	Introduced from Europe, where it grows wild on the chalky seacoasts of England, Denmark, Greece, and northwestern France. Introduced into cultivation in European gardens in ninth century A.D., but existence known hundreds of years earlier. Favors cool, moist climates and sandy loams.

REPRODUCTION	ECOLOGY	ECONOMY AND CULTURE
White flowers to 1/12 inch long, borne at tip of alternating, upward-curving flower stems. Shortest and youngest are at tip of stalk. Fruit like slightly bloated triangular purse—Latin name *Capsella* is diminutive of *capsa*, box—attached at one corner. Two cells each bear about 12 seeds. Self-pollinated.	Found blooming inconspicuously from early spring through to snows of late fall or winter, when rosettes are most apparent. Can survive drought, freezing, and flooding. One plant may produce over 2,000 seeds, most of which are eaten by small birds, even in winter when only tops are above snow.	Plant mildly resistant to 2-4-D, but a strong concentration will certainly kill it. It also yields to iron sulphate and copper sulphate, and to competition from other plant life. May be eaten as inferior salad green, either raw in sandwiches or boiled; young, tender plants said to be excellent.
Small white flowers to 1/12 inch across are carried on short stems that crowd along the flowering stalks. Petals present in earlier, but not in later, flowers. Two stamens about the same length as petals. Seed pods cluster about flowering stems. Fruit is short, flat, and round, with notch at tip.	Flowers from May through November, and may have small rosettes in winter. Being self-pollinated, it has high survival quality; well able to withstand flood or drought. Abundant seeds provide food for small birds. A common weed in dry or moist soil, along roadsides, in fields, or in waste places.	Can be killed by usual weed killers; also yields when soil is placed under cultivation by man. Used to some extent as a salad plant, but is inferior to so many others of equal abundance that it is not cultivated. The seed pods are pungent, peppery, and edible.
Petals are from pink to pale-purple to white, and usually dark-veined. Fruit to 3 inches long, lance-shaped or oblong, spongy in texture. Seeds are brownish spheres, which germinate quickly. May develop roots to harvest in 3 weeks. As flowering top develops, roots lose stored food.	Flowers in summer. To get succulent, crisp roots for eating raw, it is best to force growth by cultivating in relatively warm, early soil, although the maggots of flies and aphids may become troublesome for roots. Its taproot may draw water from depths to 18 inches.	May be grown between rows of more rapidly growing crops, thus increasing land yield. Usually planted at intervals of several days to assure constant harvest. Radishes for winter use may be planted in late summer and stored in cellar in sand until used. Leaves may affect sensitive skin adversely.
Yellow flowers with petals to ½ inch long, borne on stout stems at the tips of branches that extend upward. Fruits are round in cross section, with an erect beak nearly half the total length. There is a fine constriction around relatively few yellow-brown seeds.	Flowers from June through August. Originally cultivated for seeds, which contain a mucilage, a glucoside (sinalbin) and proteins. Seeds have an oil content of only 26—30 per cent compared to 30—40 per cent of black mustard. Not as important source of table mustard as black mustard.	Seeds should be sown over rich soil in early March. Seedlings develop quickly and may be gathered for use when about 1 inch high. Mixed with cress it makes a tasty salad. Seeds ground and mixed with water yield non-volatile oil used in mustard plaster, as lubricant, illuminant, or irritant.
Flowers light or bright yellow, about ½ inch in width; borne in clusters at tips of branches, with younger ones nearest ends. Fruits to 2/3 inch long, smooth or somewhat hairy; terminal beak about half as long as body. Dark-brown seeds are in pods that contract.	May appear in flower from May to September. Common in grain fields, where it gives unwelcome competition to the more desirable plants. Its hairy surface, though, makes it possible to use special sprays that will stick to the mustard plant and not bother others. Most effective attack is hand-pulling.	First control of field mustard is to be sure it is not present in other seed that is sown. If planted, fields of grain may be harrowed when mustard is only a few inches high and sun is hot enough to kill injured weed before it can recover. Non-edible, and of no economic importance.
Yellow flowers, to ¼ inch in width, in bright, open clusters crowned by unopened buds. Fruits, with conelike tips, are to 1 inch long, 4-sided, pointing upward, and are closely appressed to stem. Seeds are brown on outside, yellow within. The exact method of pollination remains in question.	Flowers from June through October. Oil content of seeds is 30-40 per cent more than that of white mustard seeds. Of an approximate 7,000 tons of mustard seed oil produced annually in U.S., about 78 per cent comes from Montana; with rest largely from California, Washington, Oregon, New Jersey.	Leaves may be used for greens. Glucoside from ground seeds yields volatile oil that gives flavor to familiar table mustard. Also used in making of medicines, soaps, in preparing sardines, pickles, and salad dressings. Chemical content of oil in seeds can blister skin and injure eye and nose membranes.
Light-yellow flowers, to ¾ inch across, on slender, spreading stems. Fruit to 4 inches long, with slender beak. In cooler zones, seed may be sown by mid-June, but fall sowing is best in southern climate. Seeds are brown. It is considered to be self-pollinated.	When broadcast, 4 pounds of seed required per acre; when drilled in 2-foot rows, only 2 pounds needed. Often sown with grain when grain is about 2 inches high, and with corn at last cultivation. One acre can yield to 50 tons of grain feed; 10 tons is average.	Rape is grown in Europe, and to small extent in United States, for making a lubricating oil. (America has imported as much as 15,000 tons of this oil in one year.) One good acre can support 12 sheep or 24 hogs for a month. Salt should be added to rape fed to cattle.
Flowers resemble those of cabbage, but are borne on stouter, spreading stems. Beak of fruit is neither long nor slender; is usually under ⅜ inch long. Whole fruit of rutabaga is short and compact. Flowers apparently not self-pollinating. Seeds can survive 20-30 days of freezing temperatures.	Seeds planted in deep, fertile loam at midsummer produce fall crop. In southern zones, may be sown from July through September. Seeds do best in rows 18 inches apart, then thinned to 6 inches apart to allow for root development. Will withstand slight freeze, but not a hard freeze.	Excellent source of food for man. Yields well to management and may be stored safely in cool cellar. Contains such nutrients as niacin, riboflavin, thiamine, proteins, and several elements. Rutabagas are also grown for feeding various types of livestock.
Whitish-yellow flowers in long clusters, sometimes produced only after exposure to low temperatures. Plants not so chilled known to produce 3 heads a year for 2 years, the plants yielding flowers and seeds at slower normal growth rate when removed to cooler temperatures. Self-pollinating.	In northern United States, seeds may be sown in hotbeds in January, thinned to 2 inches apart, then moved to fields. For later crop, seed is sown 6 to 8 weeks before transplanting. One pound of seed sown in greenhouse provides seedlings for 4 acres. Seed should be "hardened" against low temperatures.	Probably most important of all species of the genus *Brassica*. Grown in market and home gardens throughout the United States, with winter production increasing in South. Shrinkage varies from 7-27 per cent with temperature, ventilation, and time. May be eaten raw or cooked; popular in many dishes.

	DESCRIPTION	RANGE AND RELATIONSHIP
KALE *Brassica oleracea,* var. *acephala*	Giant kales may grow to 9 feet, but most are much lower. Leaf variation is great; some have frilled margins, some have cut or almost smooth edges. Leaves may be thick, but do not form compact heads. Color usually deep blue-green, presumably like plant from which cultivated forms developed.	Introduced into United States, but still found wild on cliffs of southeastern England. Grown widely in suitable climates. Modern varieties include those known as Siberian kale and Scotch kale, along with those differentiated by height and leaf shape, such as tree kales, curled kales, and collards.
CAULIFLOWER, BROCCOLI *Brassica oleracea,* var. *botrytis*	Stout, short stock bearing a dense, depressed, spherical head grown over by coarse, rather thick, conspicuously veined, strongly ascending leaves. Broccoli heads are smaller, the leaves are larger, and the whole plant greener than is typical cauliflower. The plant has a substantial root system.	The centers of cauliflower cultivation are on Long Island and in California. Broccoli is preferred in France and England. Asparagus broccoli, or sprouting broccoli, differs from regular variety in not producing a head: it is a special variety, *italica.*
BRUSSELS SPROUTS *Brassica oleracea,* var. *gemmifera*	Erect and unbranched stem may grow to 5 feet high; usually only to 3 feet. Leaves form crown at top, with uppermost leaves smaller than those below. Leaves about as long as they are broad; some are lobed at base. Small heads grow to about 1 inch in diameter, borne in axils of leaves along stalk.	Merely a variety of species to which cabbage belongs, as its scientific name implies. It is not cultivated in United States to the extent it is in some other parts of the world, but has become increasingly popular here. Main centers of cultivation are on Long Island and various localities on the West Coast.
KOHLRABI *Brassica oleracea,* var. *gongyloides*	Leaves to 10 inches long, relatively few lobes; 1/3 is petiole and rest is blade. Conspicuous owing to swollen tuber appearing aboveground as sphere 4 inches or more in diameter, with leaves scattered at top. Deep taproot from beneath tuber; fibrous roots at bottom.	In America, kohlrabi is popular field and garden plant grown for stock consumption; in Europe it is popular as food for humans. Sometimes considered a variety of cabbage, but is easily distinguished by tuberous stem and small-bladed leaves.
TURNIP *Brassica rapa*	Grass-green leaves, to 20 inches long. In first year they cluster at top of root; in second year they grow along stem that may reach to 3 feet in height. Basal leaves narrow and softly prickly. Rootstock forms a flat tuber, white-fleshed, often colored aboveground.	Of unknown origin, but grows wild in Russia and may have originated there. Spread throughout Europe; was introduced into Mexico in 1586 by Spanish; introduced in Virginia in 1609. Closely resembles *B. campestris* in foliage, flowers, fruits, and growing habits.
TUMBLING MUSTARD *Sisymbrium altissimum*	Erect, thin stem, up to 5 feet, fuzzy, pale-green. Loosely branched; tips turn upward and branches are stiffer toward base, making for springiness that allows plant to "tumble" when dry. Leaves petioled, parted into segments, vary in shape from linear and entire to lancelike and notched.	Native of Eurasia; was probably introduced into United States accidentally. Now established independently along roadsides, fields, and waste places. A common weed on North American continent; most troublesome in Northwest and on Pacific coast.
WATER CRESS *Nasturtium officinale*	Grows partly submerged in shallow fresh water, usually over soft, muddy areas. Stems are weak and are often tangled into a mass with the leaves. Leaves of 3 to 9 segments, with the terminal ones larger and more rotund than the lateral. Develops many roots.	A native of Eurasia, it has been introduced throughout many parts of the world. It is now thoroughly and widely established in southern Canada and throughout the United States. Most common in springs, spring-fed streams, and in clear, quiet water. May submit to some degree of cultivation.
HORSERADISH, RAIFORT *Armoracia rusticana*	Erect stems to 4 feet high, coarse in appearance, branching into slender flower-bearing branches. Leaves at base are long-petioled, to 15 inches long, with thick midrib. Upper leaves smaller, without petioles, with or without toothed margins. All leaves translucent green. Coarse, deep taproot.	Native of southeastern Europe and western Asia; has been introduced into United States and Canada. May be cultivated as field crop; occurs as garden escape, especially in deep ditches and moist waste areas. Sometimes a pernicious weed. Does not do well in sand or clay; potash fertilizers aid growth.
WINTER CRESS *Barbarea vulgaris*	Smooth, erect stems, to 2 feet high. Somewhat branched at top. Large tufts of smooth, shining basal leaves on thick petioles to 1 foot long, with crinkled edges or variously modified along margins. Upper leaves narrow, without petioles, with or without toothed margins. Root a solid, deep taproot.	A native of Europe, introduced to become widely established as common weed in meadows, gardens, and waste places. Now found from Labrador to Pacific and south to Virginia and Middle West, but areas not necessarily continuous. Thrives best in damp soil. Closely related to scurvy grass, *B. verna.*

REPRODUCTION	ECOLOGY	ECONOMY AND CULTURE
Flowers essentially like those of cabbage and other close relatives. Seeds commonly of high purity and high germination quality. Clean cultivation is necessary for superior crops. Seeds may be broadcast or sown in drills to 18 inches apart; seedlings are thinned; thinnings are sold for home use.	Some varieties can resist drought and extreme temperatures. Frost, in fact, tends to improve flavor. Will draw water from soil to depth of 21 inches. Kale will grow in almost any type of soil, but fertilization is recommended, using either 20 tons of manure or 1,500 pounds of fertilizer per acre.	More generally grown in other countries than in United States. A winter crop in southern states; late fall crop in North. In England, stout stems of tree kales are used as canes or as rafters. Other kales are grown as kitchen kales or cow kales for indicated uses.
Flowers are borne crowded on short, thick pedicels; undeveloped flowers abound. It is not considered a self-pollinating plant. Cauliflower seed is grown in Europe; it is highly sensitive to climatic conditions. Edible parts are really thick, short stalks of undeveloped flowers and supporting bracts.	Optimum temperature is 60 - 70°F., with any considerable variation causing unwanted leaf development and lack of development of edible flowering portion. Best soil is rich loam that holds moisture; sand is undesirable. Plants should be started in time to mature 4 months before killing frost.	For early crop, plants are started under glass and set out after frost danger is past and when moisture, temperature, and other conditions are favorable. Cheesecloth covers are used to keep away destructive cabbage maggot fly. Considered to be more delicate and easier to digest than cabbage.
Closely crowded flower clusters or fruits form buds along stalk; leaves are cut off as plant develops and heads crowd densely along stalk. Seeds are sown in late spring or early summer and transplanted to permanent bed when seedlings are about 6 inches tall.	In mild climates, plants may continue to yield well into winter, but where severe weather sets in, plants are lifted whole with clinging soil and set in cool cellar to continue some production. Brussels sprouts are cool-area plants, but more delicate than cabbage.	Market not so strong in America as for more generally liked or more easily produced relatives, such as cabbage or turnips. Considered a particular delicacy by many, though. All larger, outer leaves are removed, and only compact little heads are cooked and eaten.
Flowers are much like those of the cabbage, but the beak on the fruiting pod is usually conspicuously short. Plants may be started in open or in hotbeds. Slow growth, due to seasonal conditions, tends to produce a tough, tuberous, relatively unpalatable plant.	Naturally a cool-weather plant that requires a rich, deep, well-drained loam and a good water supply. Early, quick-maturing varieties are preferred for table use and later forms are used for stock feeding. Phosphate fertilizer often used with desirable results.	Much hand labor is necessary, particularly at start, in order to produce a good crop for human consumption. Plants usually sold in markets in bunches and with leaves left on; tubers should be peeled and diced before cooking. Economic value in America determined by its demand as fodder.
Yellow flowers, under ½ inch long; when closely crowded, open flowers top those not yet opened. Fruits about 2 inches long, with slender beak at free end. Seeds are small spheres; they germinate quickly and should be sown directly where plants are to mature.	Plants do not thrive in hot weather. Raised in North as early season or summer crop and in South as winter crop. Seedlings are thinned, and thinnings are sold as greens. Experiments show that seeds sown in drills yield far more than those sown broadcast.	Popular in home gardens, turnips make excellent crop because they grow well with little attention, store easily, and have good food value. Young turnips are bunched and sold for home consumption; mature ones are often stored and may be used as stock fodder.
Pale-yellow flowers, about ¼ inch across, borne on short stems along branches. Ascending or spreading fruits develop into slender, straw-colored, slightly diverging pods that break into two sections, freeing the brown seeds that are usually flattened on one side.	Flowers in June and July. Most conspicuous in late summer or in winter, when tops protrude above snow. If tops are left to mature, plant may break from root system and tumble across fields or snowbanks, dropping seeds and piling up along fence rows.	Cultivation of fields is usually sufficiently disturbing to keep weed from becoming overserious pest, but care should be taken to see that fruits are not allowed to mature, as plant's "tumbling" quickly spreads seeds. Seeds of some mustards are used as flavoring.
White flowers, to 1/6 inch across, are borne in rather open clusters at end of short stem tips. Petals are twice as long as the sepals. Slender fruits are to 1 inch long, spreading or curving upward. Seeds are arranged in 2 rows in fruit tips. Self-pollinating.	As plants are usually found in clear spring water, water cress may seem to be safe for use as food; but water may be contaminated, so unless sure of source, cress should be disinfected with wash such as chlorazene. Fresh-water shrimps and water sow bugs frequently thrive among the growing plants.	Freshly collected water cress is considered a delicacy as a salad or sandwich green, but its general sale through markets is rather limited because it is highly perishable. It should not be confused with water hemlock, which may grow in same places and slightly resembles it, but is highly poisonous.
White flowers, to 1/3 inch across, borne at stem tips in fairly open clusters. Petals twice the length of sepals. Fruits, to over 1 inch long, oblong to globular pods with short beaks, spreading or curving upward on stems. Seeds arranged in two rows. Propagation is by deeply planted root cuttings.	Flowers conspicuously from May through July. Roots are best dug in spring or autumn, as summer roots are commonly bitter. Roots dug in autumn for cultivation are planted in spring in deep, well-fertilized furrows. May be grown with cabbage, as two plants have similarly controlled enemies.	Has minor economic value in making well-known condiment that has been especially popular among Europeans. Stored roots deteriorate rapidly, so they should be ground soon after digging. Condiment made by adding vinegar, sugar or mustard to grated root.
Bright-yellow flowers, to 1/3 inch across, borne in elongated clusters at ends of relatively stout stems. Fruits spreading or upward-reaching, about 1 inch long, roughly 4-angled, about 6 times length of supporting stems. Not self-pollinated effectively.	Grows best during warm periods in winter, when leaves may protrude above snow's surface. Can be eaten in early December, when young stems and leaves are tender and about as bitter as dandelion greens. Plants appear as bright green rosettes in early spring.	Leaves rather bitter, have never become popular as food, but are eaten as a potherb. After harvesting leaves, they should be washed thoroughly, boiled in salted water. Cooking helps to kill bitterness; plants should be eaten immediately after cooking.

nature IN THE SCHOOL

Teachers who wish to combine work in natural history and geography will find the members of the Family Cruciferae most helpful. The chart section of this insert contains references to the geographic origin of a few common mustards. If teacher or student wishes to follow this up, we suggest that a copy of L. H. Bailey's *Manual of Cultivated Plants,* which should be in every school library, will prove most helpful. With that reference text and a list of some of the crucifers to be found locally in gardens, groceries, flower shops, and other places, it will become apparent that the world has been combed for these plants, which serve us in so many ways.

In the main text of this article we have suggested that the simplest way to recognize a crucifer is to remember that the flowers resemble a cross, made by the placement of the four usually equal and often conspicuous petals. Mistakes may be made in applying this suggestion, but at least it provides us with a point of departure. Remember that the four petals are not crosslike themselves, but are arranged so that they collectively resemble a cross. Also remember that mustards have six stamens.

It is true that this general rule is not always accurate. True, the petals always number four, and they are the most conspicuous parts of crucifer flowers; but there may also be four sepals around the corolla; or as is often the case, there may appear to be no sepals whatever, since in many crucifers they drop off early in the growing season. In other crucifer flowers it may superficially appear that there are but four stamens. This is because two of the six stamens are often shorter and less conspicuous than the other four.

The relative length of the stamens and the central pistil are well worth examining. Here are a few important questions to bear in mind. If there are four long and two short stamens, is either group longer, shorter, or equal to the pistil in length? If the pistil is longer than the short stamens, are the flowers either fragrant or brilliantly colored? If the short stamens are shorter than the pistils, how does pollen get from them to the pistil to effect pollination? If they cannot effect pollination, of what use may they be?

If the pistils and stamens are equal in length, or if the pistil is equal in length to *some* of the stamens, try to find out if the pistils and the stamens mature at the same time. If they do, self-pollination could be effected through the ripe stamen touching the ripe pistil. If desired, teacher or student can undoubtedly find an example of this action in some local mustards.

It would be well to observe the frequency with which mustard flowers are visited by honeybees. Would it seem that there is a relationship between the abundance of nectar-bearing mustard flowers and the size of the honey crop? Honey derived from mustard flowers contains no trace of "mustard" taste; crucifer nectar is usually of fine, light color and has a mild flavor. You may conclude from your observations of mustard flowers and honeybee activity that, while the farmer may tell you that a field of mustard is a total loss to him, the beekeeper may feel quite differently.

Mustards grow wild in a great variety of habitats, and their seeds may be collected quite easily. If you are able to identify the seed with reasonable accuracy—since flowers and fruits may often be found on one plant—make a small collection of the seeds of the local mustards. If this is not convenient, make a collection of those sold in a seed store. It should include the seeds of radish, cabbage, and a number of the other crucifers listed in the chart section. Take a strip of adhesive tape about three inches long. Bend back the tape-ends and fasten the tape to a card or sheet of paper, leaving a sticky area exposed. On this sprinkle some seeds of mustards procured in the field, garden, or seed store. The seeds will stick to the tape, and you can then write the appropriate name beneath them. What likenesses and what differences do you notice in the size, color, and shape of the different seeds? Place a piece of wet blotting paper in a Petri dish or a covered, flat glass dish. On the damp paper plant little rows of seeds of the different mustards. For comparative purposes, also plant a few rows of seeds of several other kinds of plants. Leave them on the moist paper for a few days, and notice if the mustard seeds germinate faster.

Mix a few seeds of peppergrass with some clover seeds. Dampen your finger and touch the seeds. Do the seeds of peppergrass cling more quickly, firmly, and closely to your finger than the clover seeds? Which of the seeds do you imagine would be the first to take advantage of a little moisture if they were planted in a relatively dry field, and which would be likely to start earlier than the others? The answers to these questions may give you some reasons why mustards do so well in competition with other plants.

If you have a small collection of different kinds of mustard seeds, crush a few of them separately. Wash your hands thoroughly, and while they are still wet put some of the crushed seeds between your fingers. Then close your hand. Try particularly to get some seeds of both black and white mustard for this experiment and rub crushed seeds of these plants on your wet fingers. Do you note any sensations stemming from the contact of the crushed seeds with your wet fingers? Does the same thing happen with all the mustards with which you can experiment? The results of this experiment may be temporarily disturbing, but will not be serious because the concoction can be washed off quickly.

Taste a few leaves of a number of members of the Family Cruciferae, and of leaves of common plants you know to be safe. Try lettuce as a check species, since it is bland and not a crucifer. Try cabbage and radish also to see if they are more like each other than like lettuce. You may be surprised to notice how, after a while, you can actually recognize the crucifer taste.

If you have a bird-feeding station, tack some paper cups to a board. Now cut the cups down until they make shallow trays about one-half inch deep. Fill the trays with different kinds of seeds, including sunflower, wheat, buckwheat, and so on, and then put the seeds of a few different kinds of mustards in several other trays. Birds' preferences in seeds are highly instructive.

ONLY THE HEAD of the ant lion, camouflaged against the sand, is exposed as it awaits its prey. The vicious-looking "horns" are really the animal's curved jaws, each bearing three teeth and many hairs. Fine antennae show above jaws.

Pit-digging Predator

Ant lion exhibits special techniques for gathering food

By JEROME G. ROZEN, JR. and BARBARA L. ROZEN

ONE OF THE STRANGEST combinations of characteristics in all the nimal kingdom can be found in a creaure that digs with its head, "drinks" ts prey through strawlike mouthparts, ives partly buried at the bottom of a onical pit that serves as a trap for its rey, and walks only backward. Commonly termed "ant lion" or "doodleug" in this country, it is the larval tage of any member of the neuropterus family Myrmeleontidae.

The name ant lion aptly implies that these larvae often prey upon ants. Although ants constitute a considerable part of their diet under most circumstances, they will seize and eat almost any small arthropod—insects, spiders, isopods, or myriapods. Further, there is little reason to suppose that they could not survive on a diet that was entirely devoid of ants.

Perhaps the most striking feature of the larva is the novel method by which it secures food. The ant lion digs a steep-sided, funnel-shaped pit in loose, dry earth or sand, and at the bottom buries itself except for its head. There it waits motionless, with jaws open and the head almost invisible against the background, until an ant or another small arthropod approaches. When the quarry wanders too close to the pit's rim, the sand yields beneath its feet and it slides and tumbles toward the outstretched mouthparts of the ant lion.

This ant lion is 7 mm. long from end of body to tip of jaws. Large spots on the body are sclerites. Its slender front and middle legs apparently are used to pile sand on the animal's head from underneath while it is pit-digging.

The prey's descent is hastened and usually insured by the ant lion's action of rapidly pelting the victim with sand. It quickly scoops sand on its head and jaws and snaps the head upward, thereby catapulting the grains with considerable force. If the grains do not hit the arthropod. the digging undermines it so that. in either case, both sand and prey slip farther down the pit sides. The ant lion stops tossing sand only when it has its victim securely clutched between its tonglike mouthparts or if the game escapes.

Rarely, on first try, does the ant lion clasp its prey so that the tips of its strong jaws pierce the body wall. Either the predator repeatedly throws the victim against the side of the pit until the proper hold is attained or the arthropod is momentarily released, only to be dashed with more flying sand and then recaptured. Once pinioned, the struggling prize may be partly or completely pulled under the sand and held there until paralyzed.

The sand-flipping accounts for the other common name of the ant lion. Although the person who coined the term doodlebug is unknown. he must have been a young child at the time, for who but a youngster would have discovered that if he placed his mouth close to one of the pits and chanted "doodle-doodle-doodle," the pit inhabitant would start tossing sand? The slight amount of breath released during chanting is sufficient to dislodge a few grains of sand from the pit wall. When they strike the ant lion, a shower of sand erupts from the pit. This experiment suggests that the act of sand-throwing to capture prey is a response to a tactile stimulus and not to a visual one, even though the eyes of ant lions are well developed.

The jaws of the ant lion appear as simple, elongate, curved structures, each beset with three large, inwardly directed teeth and numerous hairs. However, they are basically more complex. Each consists of a long mandible deeply grooved for the entire length of the undersurface. Into this groove fits the long, slender maxilla, the upper surface of which is flattened. Because of this flattening and the deep groove in the mandible, a slender channel is formed. This all-important channel has two functions. First, it injects one or more glandular secretions into the prey. These secretions completely paralyze the victim within several minutes and then rapidly digest its tissues, reducing them to liquid. The liquefied contents are sucked through the narrow channel into the digestive tract of the ant lion. Then the momentarily satiated predator flips the hollow carcass of its victim over the rim of the pit.

There has been considerable disagreement in the past as to how the ant lion first constructs its pit. One school of thought holds that the larva remains stationary and hurls the sand backward to one side or the other with its head and jaws. In order to pile the sand on its head and jaws, the larva closes its mouthparts so that the tips meet. Then the head and mandibles are shoveled sideways into the sand. The sand is then forcibly thrown, just as when the larva tries to knock its prey into the completed pit. The other school has observed that the larva begins pit excavation by making a circular groove in the sand. The groove is produced when the larva walks backward, with a jerking motion, just beneath the surface. Each time it stops, the ant lion flips away the sand that has fallen on head and mouthparts, tossing it outward from the center of the future pit. The larva increases the depth and width of the groove by making several such circular trips, and each circuit tends to have a shorter diameter than the previous one. The ant lion may then reverse its direction by cutting across the circle, thereby flattening the center "island." The spiraling downward continues until the pit is complete.

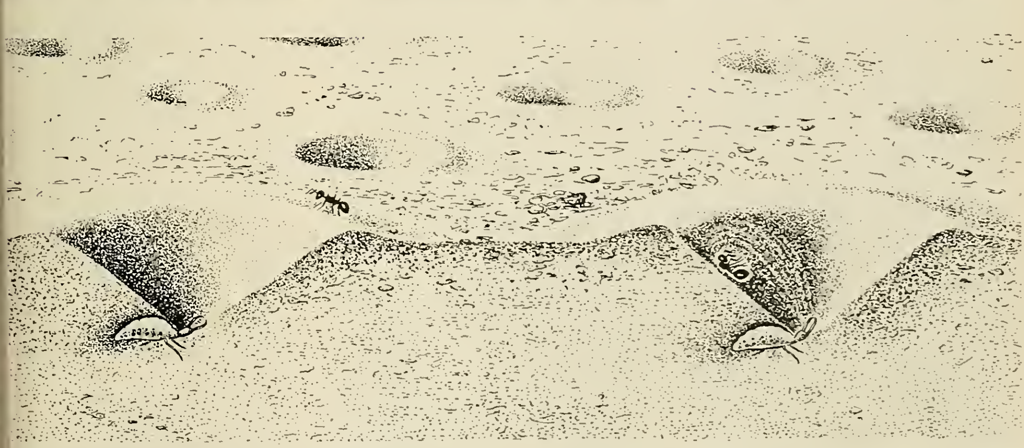
The controversy over how the pitfalls are constructed may have resulted from different species or from different stages—called "instars"—being observed. However, our observations on one species suggest that the larger larvae use both methods; that is, a spiral pit is excavated and, once roughed out, its sides are steepened and smoothed and its apex is deepened by the stationary larva shoveling from the bottom of the cone.

Apparently the front and middle legs assist in piling the sand onto the head from beneath the body, and the tip of the abdomen is definitely employed in nudging the ant lion downward and backward. However, the legs are primarily responsible for the backward thrust during digging, although just how they are employed remains unknown. Both the front and middle pair are slender. The middle ones are by far the longer and project out from the body. By contrast, the hind legs are much more robust than are the other two pairs, and are normally held partly flexed and directed backward beneath the body. In addition, they differ from the others in that the tarsal and tibial segments are fused, forming a single structure. The position and anatomy of the hind legs suggest they must provide the primary force for the retrogradient motion of the larva.

During pit construction, what happens when the ant lion encounters stones or similar objects too heavy to throw from the pit? C. H. Turner performed a simple experiment to find out, and described it as follows:

"When the stone is placed in the center of the ring, as the ant lion burrows spirally inward, there is sure to come a time when the stone will fall into the furrow. When the ant lion returns to that point it encounters the obstacle. Usually it burrows under the object and continues on part of the way around the circle. Then, turning, it backs through the furrow thus made until it has inserted the tip of its abdomen under the impediment. It then backs slowly up the slope with the burden poised upon the tip of its abdomen. The edges of the abdominal somites and the small bristles thereon prevent the stone from slipping forward, while the dirt on each side prevents it from falling sidewise. Throughout this entire upward journey the whole body of the ant lion is above the ground. It is an astonishing sight to see the insect backing in almost a straight line, up the steep slope, with the burden poised on its back. When the burden has been disposed of, usually at the edge of the pit, the ant lion turns about and returns to the bottom of the pit, usually in the furrow made by the upward struggle, and continues her digging."

Although the ant lions most often seen are those that construct pits, it should be borne in mind that only a small percentage of the species in the family possess this behavior characteristic. In the United States, members of the genera *Hesperoleon* and *Myrmeleon* are the primary, if not the only, pit-makers and the larvae of at least the latter cannot walk forward. Species in other genera may merely conceal themselves under loose sand, stones, or detritus, and wait for potential prey to happen by. This habit would seem to be a more primitive means of predation, as compared with the pit-making of the other two genera, and it is interesting to note that these non-pit-making forms can crawl both forward and backward. One species in



Funnel-shaped pits have steep sides, and are invariably constructed in loose, dry, sheltered soil. Approaching prey slips over pit rim, and ant lion, hidden at the bottom, pelts sand upward, hitting or further undermining sliding quarry.

ANT SLIDES DOWNWARD to waiting jaws of predator, which hastens capture by additional sand-pelting or by moving ant into a proper position for seizure.

India is peculiar in that it lives on tree trunks and its body is neither covered nor in any way concealed.

THE pit-making ant lions are restricted to very special environmental conditions. First, the soil must be loose and dry, and second, the pits must not be endangered by excessive rainfall. Thus, in the United States, ant lions are most prevalent in the Southwest. But as dry, sandy conditions are an important requisite for most Myrmeleontidae, non-pit-making species are also most commonly found there. However, these conditions are widely, if locally, found outside the Southwest, and consequently ant lions are rather broadly dispersed throughout the United States and all warm continents of the world. Pit-making forms may be found in great numbers pocking the ground beneath almost any overhang where the soil is dry and loose. Favorite overhangs are eaves of houses, projecting cliffs (both large and small), cave entrances, and even under leaning trees.

In describing the life history of one pit-building *Myrmeleon*, Bruce H. Kennedy, an Ohio State University student, states that the egg is an elongate, whitish spheroid, peculiar both because its surface is sticky and because it possesses two micropylar openings, one on each end. Insect eggs generally have a single micropyle—the minute hole in the egg shell through which the spermatozoa pass at the time of fertilization. The egg is deposited below the surface of the sand and immediately becomes encrusted with sand. At hatching time, the shell splits along a circular line of weakness, so that a cap is formed containing one of the micropylar pores. The young larva crawls from the egg and within 24 hours constructs a small pit, proportionate in size to the insect.

The duration of the larval stage most certainly depends upon the abundance of prey. Kennedy reports that a life cycle must take at least one year, and other authors believe some species take two to three years to mature under an optimum of food abundance. Under less favorable circumstances, the cycle can be prolonged to a considerable extent, for larvae are able to survive in spite of long periods of starvation. Kennedy has kept larvae alive without feeding for approximately 120 days, and another observer records starvation periods of up to 240 days. As with most other Neuroptera, there are three larval instars.

DR. ROZEN is Chairman and Associate Curator of THE AMERICAN MUSEUM'S Department of Entomology, and MRS. ROZEN, also an entomologist, often assists her husband in his studies.

PINIONED ANT, not yet pierced by ja
tips, struggles to escape. These tip

Toward the end of each of the fir two stages, the larva abandons its p and scuttles beneath the sand for si to ten days. At some time during th phase it casts its old integument an enters the next stage. It then construc a new pit and begins feeding again.

Before pupation, the ant lion spin a spherical, silken cocoon beneath tl surface of the soil. Whereas the si in caterpillars is a modified salivai secretion and consequently is spu from the head region, in the Myrm leontidae and other Neuroptera tl silk is produced by the Malpighia tubules. These tubules are the primai excretory organs of insects, and Neuroptera exhibit this specialized a tivity only before pupation. Since tl tubes open into the posterior part the alimentary canal, the silk extrud through the anal opening, which

ontain a paralyzing secretion that the nt lion will inject into the victim.

SECRETIONS will digest victim's tissues, turning them to a liquid that is sucked into digestive tract of ant lion, *below.* Afterward, carcass is tossed from pit.

und at the tip of the very slender, lescoping, terminal body segment. ne silk, produced as a liquid, hardens most immediately upon being exposed to air. Sand adheres to the outer yer of the cocoon where the sand ains touched the still-liquid silk. owever, the other layers of fine silk esh are completely clean and white, d the lumen of the cocoon never ntains sand. The unanswered mys-ry of the cocoon is: how is the larva le to spin the cocoon in the sand thout incorporating sand in the se? Once the cocoon is completed, e last larval skin is shed and the eam-colored pupa is exposed.

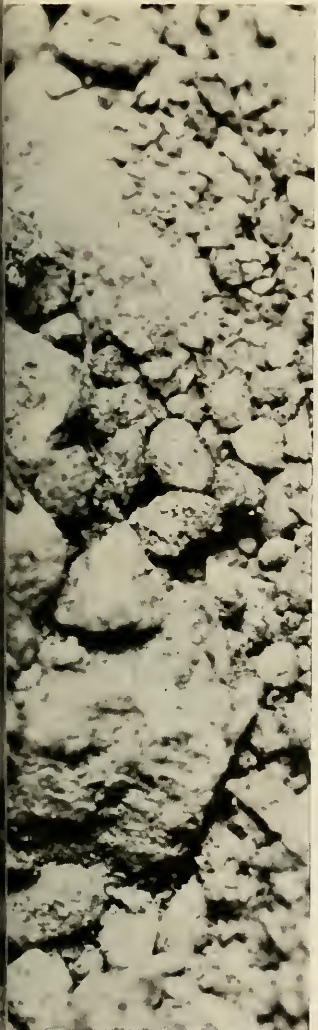
THE pupal stage lasts less than a month, during which time the or of the adult gradually appears d muscular co-ordination increases.

Sand-edged cocoon here is cut away to reveal pupa, in which eye and part of body are taking on color. At upper left of cavity is crumpled, discarded larval skin. At right is adult insect emerged from cocoon and hardening

As with all insects with pupae, this is a non-feeding stage, but the pupa of the ant lion differs from those of such common insects as butterflies, moths, and beetles. The pupae of the latter are unable to use their mouthparts and legs, and the adults crawl from their cocoons. However, in the Myrmeleontidae, the pupa cuts a hole in the cocoon with its sharp-bladed mandibles and crawls part way out, using its legs. The pupal skin then splits and the adult squeezes out and works its way through the remaining layers of sand. Once on the surface, the adult climbs a prominent object and waits until the crumpled wings and soft body fully expand and harden. While hardening, the adult discharges the entire waste accumulation of its larval and pupal stages.

The appearance of the adult is a far cry from the squat, small-eyed, wingless larva. With its delicate, long wings, slender abdomen, and globular eyes, the mild-mannered adult closely, though superficially, resembles a damselfly. However, the conspicuous antennae and pointed wings of the ant lion adult readily distinguish it.

Although their behavior is not as bizarre as that of the larvae, the adults are in many ways less well known. This is primarily because they are nocturnal or at best crepuscular. Further, the adults are strongly phototropic. There is little chance of observing them mate, oviposit, and feed under an artificial light, because their normal behavior is disturbed when they are attracted to the light. However

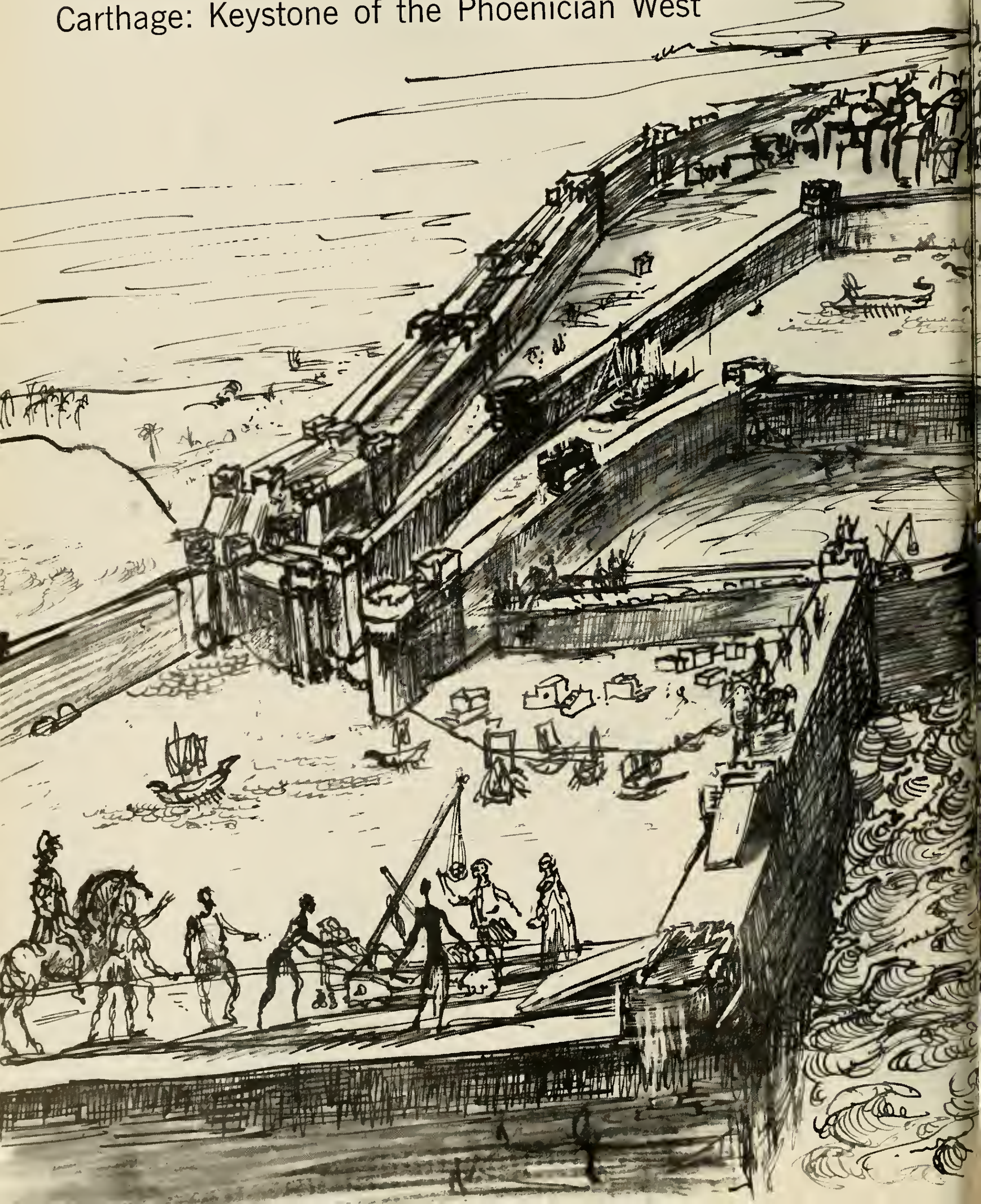


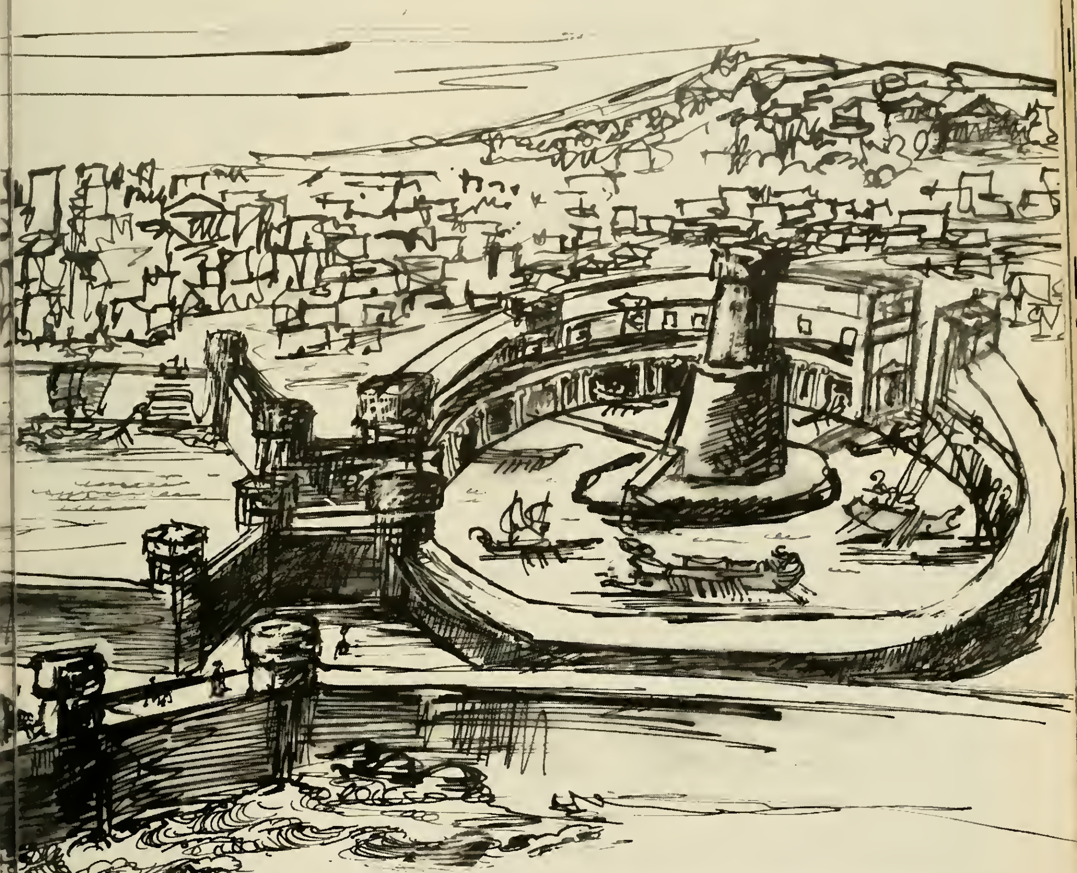
can be identified both by its pointed ings and by its conspicuous antennae.

1e European species was reported eding on small insects and fruit, and would not be surprising if they also ed upon honeydew, as do certain her Neuroptera. Their flight is sur- isingly feeble, to the extent that one onders how an individual would be ile to elude a predator. Probably the ansparent wings and dust-gray body ford protection in the form of cam- iflage. In any event, a sufficient num- r of adults survive to mate and lay gs, which in turn give rise to the next neration of dwellers in the sand.

Qart Hadasht

Carthage: Keystone of the Phoenician West





By KENAN ERIM   Illustrations by HANS GUGGENHEIM

DELENDA EST CARTHAGO! An old man's obstinacy and bitterness and the heat of a sharp rivalry have left their mark in history with these abrupt yet haunting words that few Latin students have forgotten and no student of classical history can ignore. The name Carthage, however, evokes more than Cato's repetitious advice to his fellow citizens and memories of Hannibal's great march. Even those not exposed to Flaubert's flamboyant historical fresco, *Salammbô*, still find in Carthage an aura of fascination and mystery. For, despite Flaubert and Cato, few peoples of classical times are as little-known as those energetic and hardy navigators who sailed from their proud North African capital to roam the western Mediterranean and the Atlantic Ocean. Yet the role the Carthaginians played in the evolution of Western civilization is by no means insignificant, and scholars and archeologists have contributed increasingly to the field of Punic studies since the latter nineteenth century. In the past fifty years, the excavations on the site of Carthage by the Mission Archéologique Française in Tunisia, the Société des Pères Blancs de Carthage, and the Institut d'Archéologie Tunisienne have helped to solve several historical problems and have raised others that await fuller study.

Ancient tradition ascribes the foundation of Carthage—on the North African coast near modern Tunis—to a group immigration from the Phoenician city of Tyre. Phoenicia, in ancient geographical terms, included a number of semi-independent and independent cities—including Tyre, Sidon, and Byblos—and villages along the

During second periplus, led by Hanno, group encountered band of "gorillas" on an island and gave chase. Males fled to high ground, their agility impressing pursuers. Incide[n]
may have occurred in Cameroons area of today's Gold Coas[t]

coast of modern Syria and Lebanon. Although in principle politically independent of one another, these centers were closely connected, for they had origins, language, and civilization in common. From the beginning of the second millennium B.C., the Phoenicians—and more specifically the Tyrians — became the mariners and tradesmen par excellence of antiquity. In their transactions, they succeeded in establishing a number of Mediterranean emporiums and colony-like settlements that assured them a virtual monopoly in the maritime trade of a number of commodities, not least among them such metals as tin. copper. and gold. These trading centers stretched to the confines of the world known at that time.

In the vicinity of Gibraltar, the Phoenicians founded Gades (the modern Cadiz) and Lixus: about 1200 B.C. they established themselves in Tunisia at Utica. and soon after at Hadrumetum (the modern Sousse) ; in western Sicily, in Sardinia, in the Balearic Islands, and in Malta. These various regions, with their supplies of metal and other raw materials, came under the economic dominion and supervision of the Phoenician cities along the Levant coast. In the late ninth century B.C., ancient sources relate, internal dissension in the city of Tyre led to the emigration of some elements of its population in search of a new homeland. The emigrants named their site in North Africa "Qart Hadasht," or "New City," our Carthage.

The early phases of the history of the New City are obscure and the archeological evidence is scanty. However, it seems safe to assume that a close relationship was soon re-established between Carthage and Tyre, the emigrants acquiring enough prestige in the western half of the Mediterranean to become the protectors and leaders of Phoenician commerce and settlements in the area. As Greek colonization in the West extended (and it is well to remember that the Greeks populated a hundred thriving cities scattered about the Mediterranean while the Romans were still a small, rude tribe under Etruscan suzerainty), Carthage assumed a militant, if not belligerent, role. The New City sent soldiers, arms, and fighting ships to her western Mediterranean brethren to guarantee and protect her own interests as well as the commercial rights and positions of the other Punic settlements. In short, Carthage became the banner carrier of Tyre and the mothe[r] city for Phoenicians in this part [of] the ancient world.

Carthage reached the heights of he[r] power between 535 and 450 B.C. unde[r] the able guidance of a promine[nt] nobleman, Mago, and his descen[d]ants. Not only did the city become th[e] capital of a vast sea and land dominio[n] in North Africa and in the weste[rn] Mediterranean, but also, through th[e] efforts of the Magonids. she manage[d] to check Greek expansion in that are[a] by establishing alongside her empo[r]iums a number of military stronghol[ds] that assured the continuation of Ca[r]thaginian economic pre-eminence.

During the following century, th[e] prosperity of Carthage in no wise d[i]minished. In fact, in the early pa[rt] of the fourth century B.C., Carthag[i]nian maritime supremacy manifest[ed] itself through two great *periploi*—th[e] word is a Greek one, meaning a "sa[il]ing round," and refers to circu[m]navigations of an exploratory cha[r]acter—of which we find echoes in th[e] Greek writers. One periplus w[as] achieved by a certain Himilco, wh[o] sailed northward and ventured, [it] would seem, far out into the Atlanti[c]. This voyage may even have hit Cor[n]wall and possibly Ireland: it certain[ly]

›uched Brittany and northwestern
rance in search of new sources of tin
ıd lead. The second periplus, often
ılled that "of Hanno" after its orig-
ıator, is known to us through frag-
ents of a Greek version of the Punic
xt that related its achievements. It
ems to have been accompanied by
›me immigration and to have led its
ırticipants at least as far southwest
Senegal, if not farther down along
e Atlantic coast of Africa.

HANNO, who undertook his periplus *ca.* 450 B.C., was a great ad-
iral of the Carthaginian fleet, a
andson of Hamilcar, and a member
Carthage's ruling Magonid family.
:tails of his voyage were supposedly
:orded in bronze and placed in the
nple of Baal Hammon in Carthage.
e Greek account of this periplus,
ıich Pliny the Elder characterized
"fantastic," has been preserved in
: form of the Heidelberg manuscript.
When discussing Hanno's voyage
:e map, *right*), it is well to bear in
nd two reasons for the mammoth
dertaking: the reinforcement of
:lier Punic colonies in Morocco and
ıunger for gold. Both motives lend
:dence to the theory that the Car-
ıginians permitted only a deliberately falsified account of their exploit to leave the country. Colorful distortion of the expedition's log and transposition of some geographic locations would amaze the non-Punic world with the audacity of the Carthaginian exploit while preventing others from following in the Carthaginians' wake.

Among the adventures told in the chronicle of the periplus is the following: "There was an island, similar to the first, containing a lake, inside of which was another island full of savages. There were more women than men, with their bodies covered with hair, and the interpreters called them Gorillas. We followed the males without being able to catch any because they were good climbers and defended themselves by escaping to the heights."

Although the magnitude of Hanno's feat — believed to have involved an estimated sixty ships and 30,000 persons—is beyond dispute, many passages in the story of the periplus emphasize a comment made by Pierre Cintas, of the Mission Archéologique Française in Tunisia. M. Cintas ends a summary of his discussion of the periplus by saying that, aside from the few hard facts that could be dug from the text, the document remains "a matter for poets, not for scholars."

THE third century B.C. witnessed the birth of a rivalry that was to be Carthage's undoing. The New City of North Africa and the steadily growing city-state of Rome had ignored each other for some time, occupied as each was with furthering her own interests. The Roman conquest of southern Italy, her ambitions regarding Sicily, across the narrow Strait of Messina, and the Romans' frequent unscrupulousness eventually sparked a series of conflicts known as the Punic Wars. The first of these ended with

First periplus, commanded by Himilco, followed northern route that touched Brittany and possibly Ireland as well as Cornwall. Second periplus, that of Hanno, ran southwest to Senegal, and perhaps farther, to area of Cameroons.

COMMERCIAL HARBOR at Carthage is depicted in panorami reconstruction. In the background is the *choma*, a partl

Carthage's loss of western Sicily, despite the successes of her able commander Hamilcar Barca. Internal difficulties — including the revolt of the mercenaries who comprised most of the Carthaginian armed forces—led Hamilcar in the postwar period to establish Carthage's power on more solid bases in Spain.

The Second Punic War erupted there. It was a conflict that saw the spectacular ascendancy of Hamilcar's son, Hannibal, who boldly invaded Italy from Spain, defeated the Roman legions in three great battles, and terrorized Rome. Procrastination and jealousies in the Carthaginian Senate unfortunately annulled Hannibal's enormous gains abroad. Under the spur of the famed Scipio Africanus, the Romans carried the warfare to African soil and defeated the Carthaginians at the battle of Zama in 202 B.C.

In the few decades of peace that followed, incessant efforts permitted the industrious Carthaginians to recover an aura of prosperity that inspired Cato's continuous demand that Carthage be destroyed. Indeed, Roman bad faith rekindled the conflict and forced the Carthaginians to fight for their lives in the Third Punic War (149-146 B.C.). This ultimate conflict ended with the recapture of Carthage, despite heroic resistance by her besieged citizens, and the total destruction of the city by its conquerors.

Much of our information about the life of the Carthaginians, their wars, and their ultimate defeat by Rome in 146 B.C. stems from the works of the Greek writer Appian (*ca.* A.D. 95-165). Appian's descriptions of events that occurred long before his time seem, in turn, to have been based on the writings of Polybius, whose histories are only partially preserved. Although Appian's account of the battle for Carthage and of the Carthaginian harbor installations was difficult to reconcile with discoveries of early French archeologists, a new picture has emerged with the help of aerial photography, thanks to the French Corps of Military Engineers and the brilliant scholar Jean Baradez. Appian's recital of the last battle for Carthage, presented here in Horace White's translation, can now be read with greater understanding.

According to Appian, Carthage had two harbors: one was rectangular and served mainly as a mercantile disembarkation point. The second, circular in shape, was designed for military use. Today, two lagoons—probably of artificial origin—subsist in the area of the Bay of Kram to the east of the tophet of Salammbô; most archeologists identify these as the remains o Carthage's harbors.

Appian describes the location o the city and the harbors as follows "The city lay in a recess of a grea gulf and was in the form of a penin sula. It was separated from the main land by an isthmus about three mile in width. From this isthmus a narrov and longish tongue of land, about 30 feet wide, extended toward the wes between the lake and the sea." Bara dez and earlier scholars deduced tha the isthmus was between the Sinus Uti censis—Gulf of Tunis—and the presen Lake of Tunis. Baradez places th tongue of land between the channe of the military harbor, known as th cothon, and the sea.

CONTINUING his description of Ca thage, Appian says: "On the se side [where the city faced a precipice it was protected by a single wal Toward the south and mainlan where the city of Byrsa stood on th isthmus, there was a triple wall. Th height of each wall was 45 feet, n taking into account the parapets an the towers, which were placed a round at intervals of 200 feet, eac having four storeys. In the lower spa there were stables for 300 elephant and alongside were receptacles f their food. Above were stables f 4,000 horses and places for their fo der and grain. There were also ba racks for soldiers, 20,000 foot ar

DR. ERIM, whose work has appeared before in NATURAL HISTORY, is an assistant professor in the Classics Department of New York University. MR. GUGGENHEIM, also a previous contributor to these pages, is both student of anthropology and artist.

bmerged land strip on which were situated trading depots.
upper left is entrance to the military harbor, or cothon.

)00 horse. . . . The angle which ran ound from this wall to the harbor ong the tongue of land mentioned ove was the only weak and low spot the fortifications . . . having been glected from the beginning."

Delving further into Appian's writ- gs, one discovers that: "Within the cond port was an island. and great ays were set at intervals round both harbor and the island. . . . Two nic columns stood in front of each ck giving the appearance of a con- uous portico to both the harbor and island. The admiral's house was ilt on the island, from which the mpeter gave signals, the herald de- ered orders. and the admiral himself erlooked everything. The island lay ar the entrance of the harbor, and e to a considerable height, so that admiral could observe what was ng on at sea, while those who were proaching by water could not get . . . idea of what took place within."

t is interesting to follow the final tle, which culminated in Carthage's truction, as recorded by Appian. Romans drew up a battle plan in ch one force advanced from the inland, along the isthmus, intend- to scale the high wall around thage from a low parapet between point of attack and the mainland, le the other force, led by the con- Censorinus. stormed the weak le by the harbor, mentioned above, 1 ladders raised from the land and the decks of ships. The Roman attack failed, and Censorinus then made his camp near the lagoon, "right under the wall of the enemy." It is believed that Censorinus' camp was west of the walls and the lake, in the direction of the Bay of Kram.

"When the camps were finished, Censorinus crossed the lake to get timber for building engines and lost about 500 men, who were cutting wood, and also many tools, the Carthaginian cavalry general. Himilco, having suddenly fallen upon them. . . . Nevertheless, he secured a certain amount of timber with which he made engines and ladders." The Romans attacked again.

Censorinus ordered his troops to fill in part of the lake along the tongue of land to widen the road. Then he "brought up two enormous battering rams. one of which was driven by 6.000 foot soldiers under charge of the military tribunes and the other by oarsmen of the ships under the charge of their captains." The rams were brought to the weak angle of the wall. Under the action of the battering rams, part of the wall crumbled and the Romans saw the harbor installations and the town before them. However, they were repulsed, and the Carthaginians burned their engines at night.

"Censorinus. whose camp was pitched on a lake of stagnant and impure water. under high walls shutting off the fresh air from the sea . . . moved his station from the lake to the sea. The Carthaginians, whenever the wind blew toward the Romans, towed along small boats. filled with twigs and tow, under the walls, where they could not be seen by the enemy. When they were turning the corner. and were just about to be sighted, they poured brimstone and pitch over the contents, spread the sails, and. as the wind filled them, set fire to the boats." These fireboats were driven against the Roman ships and, according to Appian, nearly destroyed the fleet.

THE Roman blockade of Carthage was ultimately effective, but by no means complete, and Appian describes occasional sallies of Carthaginian merchant ships under full sail. The Carthaginians also began to build a new fleet of triremes and quinqueremes, a new threat to the Roman ships. Scipio, who now commanded the Roman forces, conceived a new approach.

"When Scipio perceived this. he planned to close the entrance to the harbor, which looked toward the west and was not very far from the shore. For this purpose he carried a strong embankment into the sea, beginning from the strip of land which lay between the lake and the sea. and was called the tongue. and advancing it seaward straight toward the harbor's mouth. He made it of numerous heavy stones so that it might not be washed away by the waves. The embankment was twenty-four feet wide at the top,

and four times as wide at the bottom."

Since the waters are relatively shallow in this section, the construction work done by Scipio's men was little more than a continuation through the lagoon of an existing road. This action forced the Carthaginians to open up their harbor at a different point to gain access to the sea. Again, Appian has described the scene.

"The Carthaginians . . . became alarmed, and began to excavate another entrance on the other side of the harbor facing the open sea, where it was impossible to carry an embankment on account of the depth of the water and the fury of the wind. Even the women and the children helped to dig. . . . Finally, everything being finished, the Carthaginians opened the new entrance about dawn, and passed out with fifty triremes, besides pinnaces, brigantines, and smaller craft equipped in a way to cause terror."

THE new opening was some 800 to 1,000 meters north of the exit Scipio had been trying to close. Probably the exodus of the Carthaginian fleet occurred when Scipio's jetty made the old passage impracticable. But the Roman ships forced the Carthaginian fleet to return to port after a battle. However, the size of the fleet prevented it from entering in an orderly fashion. The ships then lined up at the angle formed between the wall of the inner harbor and that of the *choma*, a partly submerged strip of land, where the main fight was to take place. It was at this point that the Romans wished to gain a foothold, as it consisted of an additional defensive structure that the Carthaginians had built to protect their commercial installations. Once in possession of this bulwark on dry land, Scipio would be able to build a wall opposite that of the Carthaginians, and to launch an attack from above. Thus he would gain access to the inner harbor, and the fall of Carthage would be assured. This seems to have been exactly what happened, according to Appian.

After an initial repulse by the Carthaginians, the Romans returned and occupied the quay. Then, says Appian, " . . . they fortified it and built a brick wall of the same height as that of Carthage and at no great distance from it. When it was finished, he [Scipio] put 4,000 men on it to discharge missiles and javelins at the enemy, which they could do with impunity."

Winter came and operations ceased on both sides, but the effects of the siege began to tell on the Carthaginians. By spring Scipio was ready to move again. He attacked Byrsa, the main fortification and citadel.

Appian concludes his description of the fall of Carthage with a gripping account of the battle for Byrsa, the destruction of the Forum, and the plunder of the temples.

"Now Scipio's main object of attack was Byrsa, the strongest part of the city, where the greater part of the inhabitants had taken refuge. There were three streets ascending from the Forum to this fortress, along which, on either side, were houses built closely together and six storeys high, from which the Romans were assailed with missiles. But they captured the first few houses, and from them attacked the occupants of the next. When they had become masters of these, they put timbers across over the narrow passage-ways, and crossed as on bridges. While one war was raging in this way on the roofs, another was going on among those who met each other in the streets below. All places were filled with groans, shrieks, shouts, and every kind of agony. Some were stabbed, others were hurled alive from the roofs to the pavement, some of them falling on the heads of spears or other pointed weapons, or swords. No one dared to set fire to the houses on account of those who were still on the roofs, until Scipio reached Byrsa. Then he set fire to the three streets all together, and gave orders to keep the passage-ways clear of burning material so that . . . detachments of the army might move back and forth freely.

"Then came new scenes of horror. he fire spread and carried every- ing down, and the soldiers did not ait to destroy the buildings little by tle. but pulled them all down to- ether. So the crashing grew louder, ıd many fell with the stones into the idst dead. Others were seen still liv- g, especially old men, women, and oung children who had hidden in the most nooks of the houses, some of em wounded. some more or less ırned, and uttering horrible cries. ill others, thrust out and falling om such a height with the stones, nbers, and fire. were torn asunder to all kinds of horribles shapes, ushed and mangled. Nor was this the d of their miseries, for the street eaners, who were removing the rub- sh with axes, mattocks, and boat- ooks. and making the roads passable, ssed with these instruments the dead d the living together into holes in e ground. sweeping them along like cks and stones or turning them over th their iron tools, and man was ed for filling up a ditch. Some were rown in head foremost, while their gs, sticking out of the ground, rithed a long time. Others fell with eir feet downward and their heads ove ground. Horses ran over them, ushing their faces and skulls, not rposely on the part of the riders, but their headlong haste. Nor did the

Aerial view of Carthage is overlaid with probable outline of harbors. The drawing, *below*, is reconstruction of cothon's arcade and admiral's island.

street cleaners either do these things on purpose; but the press of war, the glory of approaching victory, the rush of the soldiery, the confused noise of heralds and trumpeters all round, the tribunes and centurions changing guard and marching the cohorts hither and thither—all together made everybody frantic and heedless of the spectacle before their eyes."

THE fierce battle for Byrsa continued for six days and nights, Appian relates. During this time, "Scipio toiled without rest." Finally, on the seventh day, ". . . some suppliants presented themselves to Scipio bearing the sacred garlands of Aesculapius, whose temple was much the richest and most renowned of all in the citadel. These, taking olive branches from the temple, besought Scipio that he would spare merely the lives of all who were willing to depart on this condition from Byrsa. This he granted to all except the deserters. Forthwith there came out 50,000 men and women together, a narrow gate in the wall being opened, and a guard furnished for them. The Roman deserters, about 900 in number, despairing of their lives, betook themselves to the temple of Aesculapius with Hasdrubal and his wife and their two boys. Here they defended themselves a long time with ease although they were few in number, on account of the height and precipitous nature of the place, which in time of peace was reached by an ascent of sixty steps. But, finally, overcome by hunger, want of sleep, fear, weariness, and the approach of destruction, they abandoned the enclosures of the temple and fled to the shrine and roof.

"Thereupon Hasdrubal secretly fled to Scipio, bearing an olive branch. Scipio commanded him to sit at his feet and there showed him to the deserters. When they saw him, they asked silence, and when it was granted, they heaped all manner of reproaches upon Hasdrubal, then set fire to the temple and were consumed in it. It is said that as the fire was lighted the wife of Hasdrubal, in full view of Scipio, arraying herself as best she could amid such disaster, and setting her children by her side, said, so as to be heard by Scipio, 'For you, Romans, the gods have no cause of indignation, since you exercise the right of war. But upon this Hasdrubal, betrayer of his country and her temples, of me and his children, may the gods of Carthage take vengeance, and you be their instrument.' Then turning to Hasdrubal, 'Wretch,' she exclaimed, 'traitor, most effeminate of men, this fire will entomb me and my children. But as for you, what Roman triumph will you, the leader of great Carthage, decorate? Ah, what punishment will you not receive from him at whose feet you are now sitting.' Having reproached him thus, she slew her children, flung them into the fire, and plunged in after them. With these words, it is said, did the wife of Hasdrubal die, as Hasdrubal should have died himself. . . .

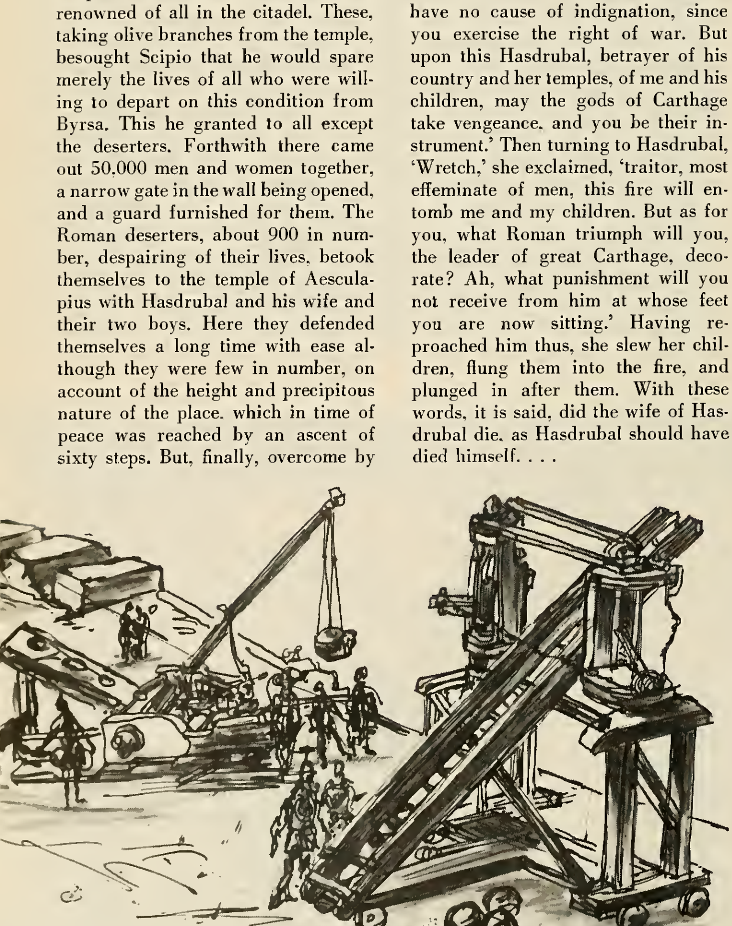
"Carthage being destroyed, Scipio gave the soldiers a certain number of days for plunder, reserving the gold, silver, and temple gifts. He also gave numerous prizes to all who had distinguished themselves for bravery, except those who had violated the shrine of Apollo. He sent a swift ship, embellished with spoils, to Rome to announce the victory. He also sent word to Sicily that whatever temple gifts they could identify as taken from them by the Carthaginians in former wars they might come and take away. Thus he endeared himself to the people as one who united clemency with power. The rest of the spoils he sold, and, in sacrificial cincture, burned the arms, engines, and useless ships as an offering to Mars and Minerva, according to the Roman custom."

ALTHOUGH the symbolic sowing with salt that followed Carthage's defeat meant the end of Punic politico-economic pre-eminence in the western Mediterranean, it did not obliterate the name of Carthage from history. Barely twenty-four years after the fall, an attempt was made by the reformer Gaius Gracchus to establish a Roman colony on the site. The effort was doomed to failure because of patrician opposition to Gracchan measures. In 44 B.C., Julius Caesar succeeded where Gaius had failed and gave the site to veteran soldiers and civilians.

Within ten years, Carthage was rebuilt and resumed a position of note in North African affairs. Her advantageous situation allowed her to regain prosperity and, in the following centuries of the Roman Empire, she could boast of a magnificent series of buildings and monuments. In the early fourth century A.D., at the time of the barbarian invasions, she even served as one of the last strongholds of the Empire to the West, until conquered by the Vandals in A.D. 439.

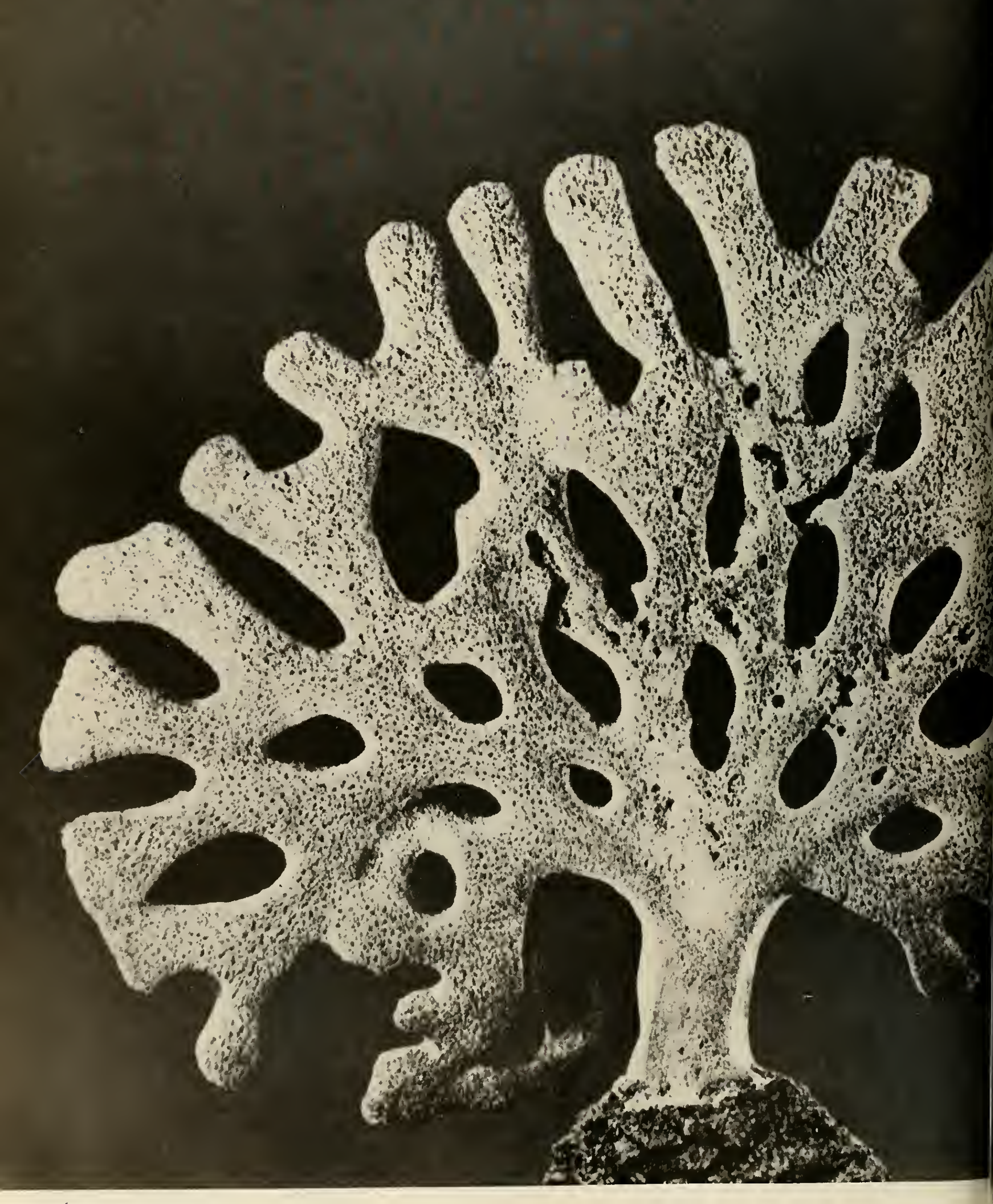
Despite liberation by the great Byzantine general Belisarius in A.D. 54[illegible] —and some further imperial patronage—Roman Carthage sank fast thereafter: it was a scarcely populated city already close to oblivion, that the Arabs seized in A.D. 696 and reduced to silence until the spades of nineteenth-century archeologists began to conjure up the phantoms of the past.

(To be concluded in April)



CARTHAGINIAN CATAPULTS, on parapets, showered missiles on Roman attackers. At right, captive Romans are tortured and killed as Roman ships bring a ram to batter the weak angle of the wall round Carthage's harbor installations.

Sponges and their



World

Primitive animals reveal complex anatomy

By Raymond Rasmont

To the layman, a sponge is essentially that brown, elastic, and incredibly porous item used in the bathroom and the garage as a cleaning tool. But how many laymen have ever seen the animal itself? How many have the slightest idea of what the live animal looks like? All biologists know that this sponge (provided it is not a synthetic one) is the peculiar skeleton of a most primitive marine animal. Certainly, the well-informed naturalist will be able to discover some fresh-water forms, or to gather some marine species from the seashore at low tide. But the true kingdom of sponges begins where the naturalist's field usually ends: beyond and below the extreme low-water level.

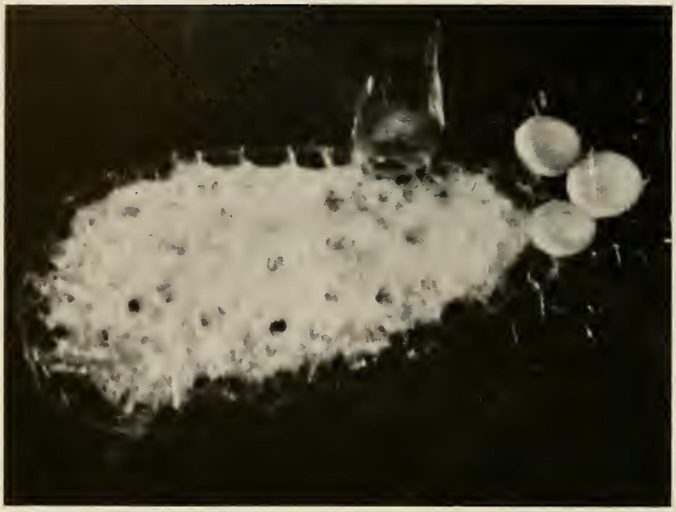
I should probably say "where this field *once* ended," for the increasing popularity of skin diving has opened wide the gates to the beauty of submarine life. In the last few years, thousands of sportsmen and field naturalists have invaded a narrow fringe of sea, twenty fathoms deep, that borders all the continents. There, it is as impossible to ignore the sponges as to ignore the lichens in a mountain forest: they are everywhere. Each rocky wall, each crevice, each tuft of seaweed may bear several sponges of various shapes and colors. But how are we going to recognize them among the pullulation of algae and coelenterates, bryozoa, and tunicates that share the same habitat? To that question there is no clear-cut answer. For example, a tenacious, gray, figlike mass is a sponge *(Ircinia)*, and so is the tiny, white pellicle *(Reniera)* that in places encrusts *Ircinia* like a mold. Still another sponge *(Hymeniacidon sanguinea)* is a coral-red crust that may cover several square feet of rocks. Others are orange-yellow boughs, branching from a bottom rock like delicate deer antlers *(Axinella polypoides)*; large, brown "goblets" among the tufts of eelgrass *(Calyx nicaeensis)*; or spherical yellow "sea-oranges" rolling about unattached on the ocean's bottom *(Tethya lyncurium)*.

If we want a clue to the anatomy of sponges, we must leave the depths of the sea and bend over our microscopes. The rearing of sea sponges is a very difficult task. The animals seldom survive more than a few days—or even a few hours—in an aquarium, and few inland naturalists can afford to maintain a sea-water aquarium. Therefore, in what follows, we shall concentrate on the fresh-water species that are spread throughout the world and are particularly abundant in the United States. Perhaps the reader will wish to make his own observations. So let us start with a young fresh-water sponge, of the family Spongillidae, and put it under the microscope—or, if possible, a good stereoscopic binocular.

At first sight, the animal appears as a circular or oval dome, bearing near its top a long, barrel-shaped chimney, the terminal opening of which is called the osculum. The surface of the dome bristles with fine, transparent needles, the spicules. The wall of both dome and chimney is an amazingly thin membrane, a two-layered epithelium of flattened, polygonal cells. The dome membrane stretches above an empty space, and is supported by spicules like a tent on its poles. It is transparent, allowing us to see the inner mass of the sponge that lies within. This mass at first sight appears as a dense aggregation of spicules, and of innumerable translucent spherules, scattered at random. However, when we look with more attention, we see that the empty spaces, surrounded by the spherules, form branching ducts.

Ankel and Eigenbrodt have devised a most ingenious technique to clarify the picture of the inner organization of the sponge. On a microscope slide, they fix two pieces of very thin glass. The space between these two forms a "brood chamber." When a sponge hatches in this groove, a part of its body grows between the thin glass and the slide. In such a "sandwich" preparation, we can actually see that the spherules make up the lining of ducts.

Representative of most varied group of sponges—Demospongiae—this "horny" specimen is merely a spongin skeleton.



YOUNG SPONGE has hatched from three globular gemmules. To their left is the transparent oscular chimney; spicules support the tight dermal membrane.

CRUSTLIKE SPONGES such as these may spread over many square feet. Radiating veins are excurrent ducts converging at the bases of several oscular chimneys.

These ducts branch as do roots, the thinnest ones at the outer edges, and the thickest ones at the very base of the oscular chimney. Other ductlike spaces extend between the channels of this system. Thus, the spherules form the walls of two channel systems.

When one observes a spherule with a good microscope, one gets the impression of a continuous, fast movement. Its origin can be discovered with specially stained preparations, the highest magnifications of the optical microscope, and the use of the electron microscope.

EACH spherule proves to be a chamber lined with a single-layered epithelium composed of very peculiar cells, called choanocytes. On its inner surface, each of these cells bears a long flagellum, which is surrounded at its base by a cylindrical or conical collar of cytoplasm. The structure of this collar has long been discussed; it seems now that it is not a continuous wall, but rather is a palisaded row of distinct, delicate cytoplasmic structures. It is the restless motion of the many flagella that gives the spherule its appearance of continuous vibration.

We have seen that these spherules — flagellated chambers — are aligned along the branching ducts. In fact, they open broadly into these channels, and the flagella are directed toward the aperture. Between the choanocyte cells other inconspicuous openings allow water to flow into the chambers from the open space that separates the ducts and extends under the transparent dermal membrane. Since this latter membrane is pierced with very small holes, the dermal pores, a continuous flow of water is sucked from the aqueous world surrounding the sponge through the "incurrent spaces" and into the flagellated chambers. From there, the motion of the many flagella propels the water down branching "excurrent channels" toward the osculum.

The moving water allows both respiration and excretion throughout the whole body of the sponge. It also provides food for the sponge, since among the countless microscopic particles such as bacteria, algae, and the like which are suspended in the water those of suitable size and properties are taken up and digested by the sponge cells. What these "suitable properties" are is still an open question. However, the data accumulated from my own experiments indicat

that killed bacteria may provide sufficient food to insure a sponge's growth and reproduction. It is thought that the collars of the choanocytes are most efficient in the capture of food particles: their palisaded structure seems to act as a filter, straining the current of water. The oscular chimney is at its narrowest at the osculum itself: the result is that filtered water is expelled with relatively great velocity away from the dermal pores, minimizing the possibility of refiltration.

From all of this description, it should be apparent that a sponge is essentially an intricate system of cavities contained within delicate epithelial membranes. But such a structure, if devoid of a framework, could not withstand the stress of the constant stream of water that passes through it. It is not surprising, then, to find that there is such a framework consisting of spicules. Each spicule is a transparent, double-pointed needle of silica, surrounding one organic axial thread. Each is formed by a single cell, which concentrates the silica, despite the very small amounts of this mineral found in fresh water—between 10 and 15 milligrams per liter. Some isolated spicules strengthen the walls of the channels: most of them are soldered to each other by small amounts of spongin, a transparent, elastic material. In this way, they form a light but resistant framework, somewhat similar to a tubular scaffolding. The outer spicules of the framework cross the subdermal space, and thus act as supports for the external membrane.

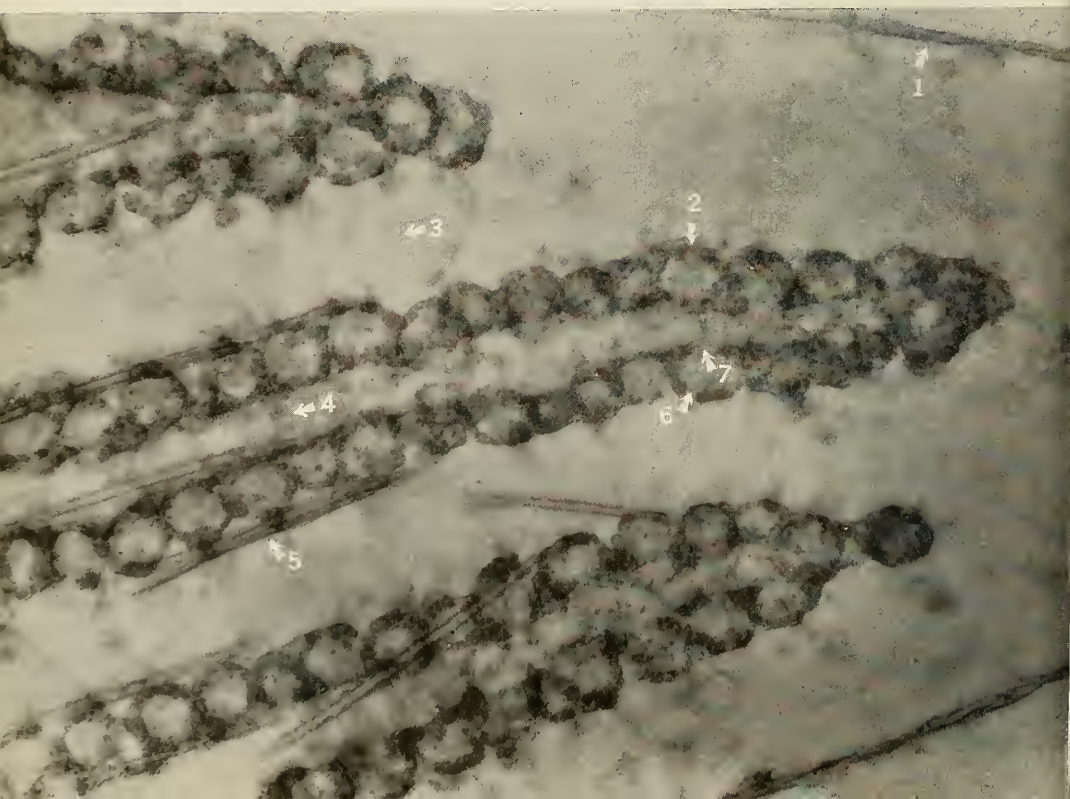
To complete the picture of our sponge, we must say a word about its mesenchyme. This is a very loose tissue, consisting of amoeboid cells of various types and functions. This mesenchymic tissue is located primarily at the base of the sponge, but many amoeboid cells are spread throughout the sponge's body, especially in the incurrent spaces between the flagellated chambers. The role of the mesenchyme is very complex indeed, and is still poorly known. Let us only say that its cells take part in the synthesis of spongin, in digestion and storage activities, and in both sexual and asexual reproduction.

There is one characteristic common to the little fresh-water sponge just discussed and all the marine species. All consist of one or more cavities, lined with collar cells, where the water

Goblet-shaped sponge, about one foot across, is *Calyx nicaeensis.* As do most sponges — despite wide differences in appearance—it has a siliceous skeleton.

Antler-like branches of a siliceous sponge, *Axinella polypoides,* are orange in color. Specimen was photographed at depth of 10 fathoms in Mediterranean.

Three gemmules hatched in "brood chamber" between glass slips, edges of which can be seen as dark, vertical lines, *above.* Higher magnification, *below,* reveals sponge parts: (1) dermal membrane; (2) flagellated chamber; (3) incurre space; (4) excurrent duct; (5) spicule; and gaps for water pass (6) from incurrent spaces and (7) into excurrent duct



DR. RASMONT, Secretary-General of Belgium's Royal Zoological Society, is a zoologist with the Free University of Brussels. He has studied sponges in both the laboratory and the field.

ows in through numerous small pore penings and out through one or a few ide oscula. Except for this, certain ther anatomical structures vary over wide range and these variations elimit the three major groups of ponges—the Demospongiae, the Calarea, and the Hexactinellida.

The most primitive sponges to be und in the sea are mere cylindrical ıbules, consisting of a thin wall that lined with an epithelium of collar ells. Water flows directly from the utside through very numerous, small ores that pierce the wall, and passes ward the free end of the tubule, hich is the osculum. This, the asconid type, is the least complex sponge rm. Next in order of complexity are e syconoid sponges. In these, many ıbules, each of which is equivalent to small asconoid sponge, direct their ater flow into a central, excurrent wity that is devoid of collar cells.

OF a still more intricate structure are the leuconoid sponges, in hich the choanocyte epithelium is restricted to many isolated flagellated ambers, connected directly to both e incurrent and excurrent channel stems. In this way, the filtering surce of this type of sponge has been creased a great many times, and this s contributed to their success in rms of over-all size of individual onges and numbers of species.

Sponges not only differ in the arngement of their choanocyte epitheım. Also, and even more markedly, ey differ in the disposition and nare of their skeletons. Despite our rlier generalizations for the Demoongiae, a few have no skeleton whatever. Others, including all the asnoid and syconoid species and even me of the leuconoids, are supported a calcareous skeleton, consisting of lcite needles in a wide variety of rms—the Calcarea.

The primary skeletal elements are ng, with sharp or blunt ends, and me are even provided with a threeanched head. In addition to these rger elements, called megascleres, any species bear minute spicules of e most beautiful and varied shapes

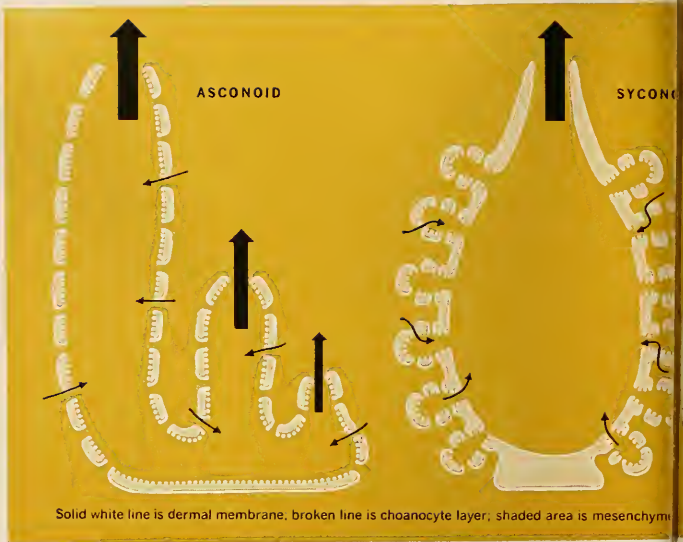
ISOLATED CHOANOCYTE CELL, with its flagellum hanging from collar-palisade of cytoplasmic structures, is seen in an enlargement of 12,000X magnification.

—the microscleres. Often, as we have seen from our fresh-water example, the spicules are soldered together with spongin, but in the so-called horny sponges, the spongin has wholly replaced the siliceous spicules as a skeleton, and forms a continuous network. In some species, this spongin network is especially dense, supple, and regular; these are the ones that are customarily used as bath sponges.

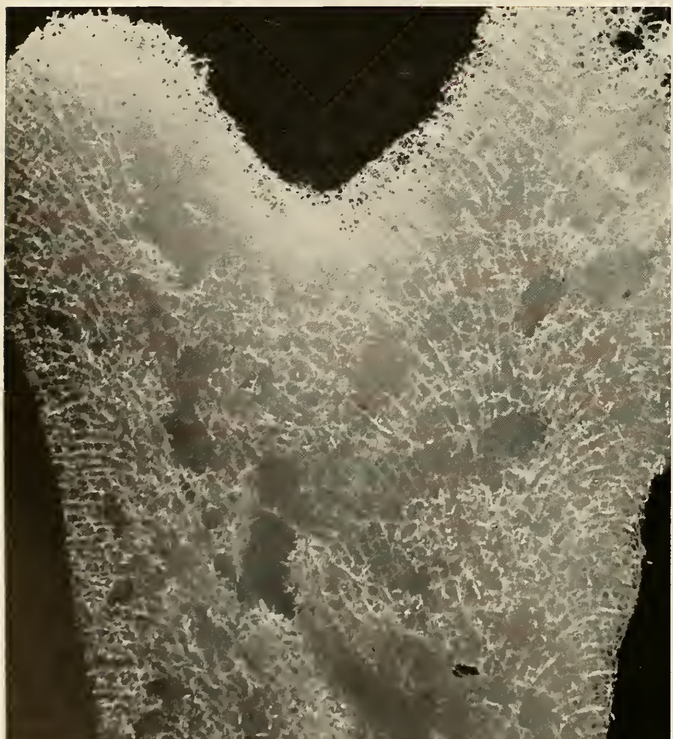
In our final group—the Hexactinellida—the sponge's skeleton is wholly siliceous and inflexible. Typical megascleres of the species in this group consist of six siliceous rays, projecting at right angles from a common center and fused at their tips with silica. When cleaned of all flesh, such skeletons seem to be made of thin strands of glass. These "glass sponges" never live in coastal areas, and are seldom dredged from depths of very much less than fifty fathoms.

As we have noted, only a single family of sponges among those possessing a silica and spongin skeleto[n] has been able to succeed in fresh water[,] the spongillids. Members of this famil[y] are to be found throughout the worl[d] in ponds, streams, and canals, but th[e] conditions controlling their distribu[-] tion are still poorly known. They ma[y] be absent from the whole length of [a] brook, except for a single sluice tha[t] will be covered with the animals. The[y] may be limited to tiny encrustation[s] on a pebble on the river bed, or the[y] may cover several square feet of [a] stone embankment. Some specimens[,] especially those of standing waters[,] ponds, or quiet streams, branch from [a] narrow base like deer antlers. Ther[e] appears to be only one rule governin[g] their spread: their absolute need fo[r] a solid substrate in relatively clea[r] water, as opposed to oozy bottoms an[d] agitated or turbid waters.

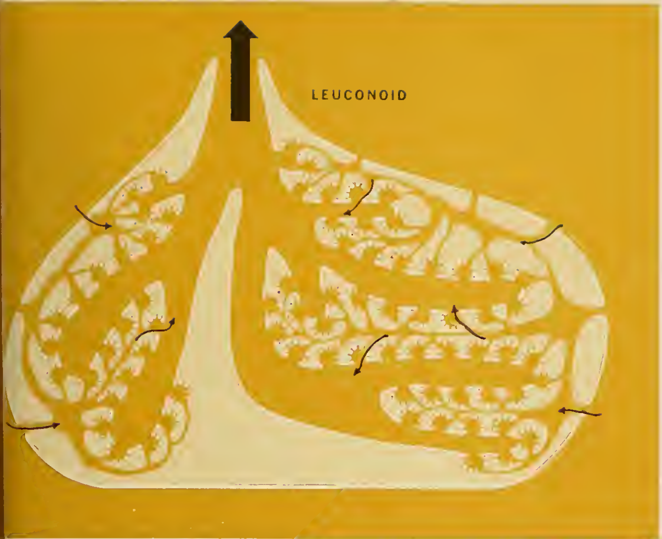
The color of the spongillids is [as] variable as their shape, ranging fro[m] dirty yellow, through gray, to a[ll] shades of brown or green. The gree[n] tinge is due to the chlorophyll of m[i]croscopic green algae that are withi[n] the sponge cells. But gray or green, fl[at] or branched, the fresh-water spong[e] can be identified by three features: th[e] dermal membrane pierced with oscul[a,] the minute spicule bundles supporti[ng] it and, non-microscopically, by th[e] very strong, unpleasant, and typic[al] smell of the crushed sponge.



THREE STRUCTURAL GRADES of sponges, arranged in order o[f] complexity, have same basic anatomical elements. In al



ORDERED ARRANGEMENT of the siliceous spicules forms skeleton of this marine sponge. Minute amounts of spongin bind spicules together, making for rigidity.

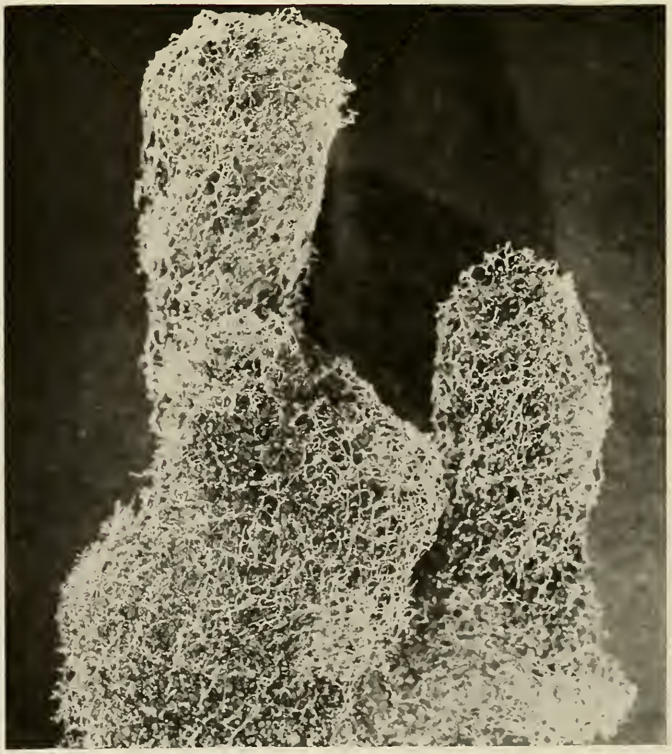


hree, the water must pass through dermal pores, past the lagella of the collar cells, and out of the osculum at top.

If one looks for them in late summer or autumn, another characteristic will nake fresh-water sponges easy to recognize. They will be stuffed with a great number of hard, brown spheres. These small ($^1/_3$ mm.) bodies are the gemmules. The core of each is a dense aggregation of undifferentiated cells, full of food reserves, enclosed in a complex shell made of different spongin layers, and strengthened by numerous microscleres. The structure of the gemmules and of their spicules is so characteristic for each species that they form the basis of systematic identification and classification.

FROM a physiological, although not from a genetic, point of view, we may consider each gemmule as a multicellular "egg." When the sponge dies, its skeleton usually remains fixed to the substrate, with thousands of gemmules entangled in it. These hatch during the following spring, and the resulting young sponges readily fuse into a large individual that occupies the parental skeleton and increases it by further building. Gemmules are so resistant to freezing and drying that one may keep them in a refrigerator or in a bottle for years, and then hatch them simply by placing them in suitable conditions. These sponge "eggs" are a very necessary adaptation on the part of the fresh-water sponges in temperate zones where the climate alternates between cold and warm or dry and wet. They are seldom, if ever, produced by equatorial sponge species, where the climate is less variable.

The physiological mechanisms that insure the formation of gemmules one year and allow their hatching the next, are very intricate, and are still little-known. In Belgium, for example, the species *Ephydatia mulleri* forms most of its gemmules as early as June. Supposedly, they remain unhatched throughout the entire summer and autumn, although climatic conditions during those periods are conducive to active life—certainly at least as conducive as those prevailing in the following spring, when hatching actually occurs. How can this be accounted for? Experiments have shown that the gemmules of this species are physiologically unable to hatch unless they have previously been exposed to low temperatures for several weeks. If in summer one takes such gemmules out



TANGLED ARRANGEMENT of spongin forms skeleton of this sponge. Its mesh is too large to make a bath sponge, but it gives fair idea of how they are built.

of the sponge and puts them in fresh, clean water at 70° F., they may remain unhatched for weeks. But if one first keeps them in a 40° F. refrigerator for six weeks, they may hatch within a few days at 70° F.

Besides their asexual reproduction through gemmules, the fresh-water sponges are also able to reproduce sexually like all the other sponges. Their fertilized eggs metamorphose into drifting, planktonic larvae that eventually settle in other locations. Sexual reproduction occurs at a very precise time of the year, and planktonic larvae are to be found only for a few days in early summer.

If gemmules of spongillids are scattered at random in a Petri dish, some of them may hatch close to one another. As soon as the young sponges come into contact, they fuse and grow into a single one. Those that hatch from a single gemmule and remain isolated, however, are clearly small, individual sponges. They originated from one gemmule, developed an osculum and an organized system of water ducts. But those that hatched separately from several gemmules and fused together also show an integrated duct system and a single osculum. Without a doubt, they also are individuals, for the question of whether hatching gemmules will give rise to one or more individuals does not depend on essential properties. Instead, the forms depend on such extrinsic characteristics of the surrounding medium as the distances between gemmules, the suitability of the substrate, and similar variables.

This, of course, is true only when the gemmules in question are genetically similar, as they surely are when produced by a single sponge. If, on the other hand, gemmules of different species hatch near each other there will be no fusion.

The problem of individuality is one of the most puzzling ones encountered in the study of sponges. At first glance, the notion of "individual" seems to be perfectly clear-cut. Anyone conceives clearly what *a* cat, *a* sparrow, or even *a* barnacle is, even if the latter is generally found in dense populations. And though a domestic bee is unable to live when cut off from the swarm, it remains, by itself, an individual with its own anatomy, physiology, and behavioral patterns.

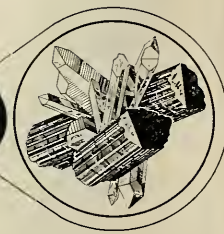
A sponge, however, is neither a colony nor a well-defined individual, but an "occasional individual." This is strikingly demonstrated by an experiment performed as early as 1907. If a large sponge is squeezed through a fine silk sieve, the resulting juice contains, among other debris, intact isolated cells, clusters of choanocytes, but no organization. If this liquid is then diluted and kept in a Petri dish, the cells will sink to the bottom, and will move about like amoebae. As a result, when they happen to meet each other they aggregate into spherical clusters, and, remarkably, they occupy, within the clusters, those places that correspond to their former specialization in the original sponge. As my Belgian chairman, P. Brien, has shown, if the proportion between the different specialized cell-types for fresh-water sponges is suitable, each such filtered aggregate will live and will eventually become a small separate sponge—an occasional individual.

Whereas other metazoans are unable to regenerate completely, once their tissues are disintegrated, these experiments make it clear that sponges are able to regenerate their whole organization, starting from separated cells. They seem to have evolved along a different pathway from the true Metazoa. Perhaps they deserve the name Parazoa, or "side-branch animals," which is what they are usually called.

Siliceous spicules of the fresh-water sponge *Ephydatia mulleri* have been magnified 150X and then photographed by a direct projection on sensitized paper. Rodlike forms are megascleres; the smaller, variformed bodies are microscleres

NATURE IN

ROCK & MINERAL



By Paul Mason Tilden

During the year just passed, the blast furnaces of the United States poured forth nearly a hundred million tons of iron and steel. This was not a record-breaking performance, to be sure; nevertheless, it resulted in the production of a weight of metal quite beyond the grasp of the mind—a figure that is really more of a statistic than a reality.

It is not the purpose of this article to dwell on the number of automobiles, aligned bumper to exhaust, that this mass of metal could represent, nor the vast number of rusting cans that it could add to the middens of the nation. Rather, it might be interesting to compare this torrent of metal with the relatively minuscule production of this country's earlier days, when the rifle, ax, plow, and kettle were still symbols of a young nation. Iron, then as now, was the lifeblood of comfortable existence; but a single modern blast furnace can produce more iron in a few days than most of the earlier furnaces could run in a year.

If you wander the byways of the eastern third of the country today, you will drive through villages that still bear such names as Harford Furnace, Tyson Furnace, Gilmanton Iron Works, or Clifton Forge, to name but a few. Each of these localities was, as may be guessed, a site of one of the innumerable small furnaces that supplied an earlier America with a large part of its iron and steel. Despite their small sizes and tiny outputs, ranging from two or three tons of metal a week to perhaps a hundred, their product was considered so vital to the public welfare that in at least one of the American colonies iron furnace employees were exempted by legislative order from the labor upon public highways expected of able and taxable colonists. These small ironmaking operations date from our earliest days down to the closing decades of the past century. Then the great floods of low-cost iron ore from the Mesabi iron range of Minnesota, and from other Minnesota and Michigan deposits, signaled the beginning of America's real iron age and stilled the charcoal-fired stone stacks of the small operators. Most of these old structures have long since succumbed to the assault of time and weather—and perhaps local need for building stone—but here and there a huge stack stands as a memorial to the early ironmasters.

The iron minerals that fed these small furnaces were of four kinds. The two iron-oxide minerals, magnetite and hematite, furnished a substantial portion of the total ore that was used; the hydrous iron oxide, limonite (including the variety called "bog ore"), was important; while the fourth mineral, used to a much lesser extent, was siderite, the carbonate of iron. All of these minerals, as furnished by the mines to the furnaces, carried other elements, such as titanium, phosphorus, manganese, or sulphur, as contaminants. An excess of any of these "trace" elements in the crude ore often spelled disaster for the furnace operator, who was not likely to be a metallurgist; they inevitably led to a product called "red-short," in allusion to its brittleness and unworkability at a red heat.

There is nothing particularly spectacular, either in color or form, about any of these four iron minerals so important to the early ironmakers, although good specimens of each should certainly be found in the cabinets of every amateur mineral collector. Specimens of all of them may still be found around many of the old furnace sites, especially if the collector is fortunate enough to locate the site of the crushing mill, usually an adjunct to a furnace, or the dump on which low-grade material was thrown.

Massive magnetite is found in heavy, dull, weathered lumps that, when broken, exhibit sparkling black interior

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Paul Mason Tilden, formerly an Editor of Nature Magazine and a rock and mineral collector himself, now continues his regular column in the pages of the combined magazines.

GNETITE, specimens of which can often found near old crushing mills, is dull on outside. Interior shows crust of partly formed crystals on surfaces of cavities.

ON ROSE," a rosette-like and shining ck formation of some hematite is caused when flattened crystals grow in a parallel formation, as in the Swiss specimen, *above.*

faces: cavities may show small or tly formed crystals that have some es of the octahedron.

he second mineral. hematite. is likely be more variable in its appearance. hematite commonly used in the early naces—the so-called specular hema- —may also be found in heavy lumps und the old works as aggregations of elike particles, with a brilliant metal- sparkle on freshly broken surfaces. third mineral. limonite—referred to "brown hematite" by the early fur- e operators—is not so common around old workings because it weathers rather quickly. When it is found. however. it should appear as soft yellow or reddish lumps of no apparent crystalline structure. and with a strong tendency to stain the collector's fingers a bright yellowish brown. The "bog iron" that was used to a considerable extent was a variety of limonite, formed under certain conditions in stagnant water that is heavily charged with dissolved iron salts. (The thin, iridescent "scum" often to be seen on the surface of many bogs and swamps today is actually oxidized iron. which

eventually sinks to the bottom of a pool as the mineral limonite.)

Siderite, the carbonate of iron, wa[s] not generally used in the early furnaces as an ore; but specimens may still be found now and then near the old works as moderately heavy, brown lumps tha[t] exhibit glassy, rather than metallic, frac[-]ture surfaces when freshly broken.

NOT long ago I had the chance t[o] spend some time at the site of an ol[d] New England iron furnace; to examin[e] the huge blast stack, still in an excellen[t] state of preservation; and to thum[b] through the yellowed books of the pro[-]prietors. This was the Franconia Fur[-]nace, a nineteenth-century ironmakin[g] venture probably typical of the hundred[s] then scattered up and down the easter[n] seaboard, though perhaps somewha[t] longer-lived than most.

During the first years of the nineteent[h] century—probably between 1802 an[d] 1805—the New Hampshire Iron Factor[y] Company erected a blast furnace, with a[n] ore crusher, casting foundry, and blac[k]smith shops, on the banks of the Ga[le] River, not far west of the heavily fo[r]ested Franconia Range of the Whi[te] Mountains. The setting for this ente[r]prise was characterized by the sta[te] geologist of the day as "a perfect wi[l]derness"; and, indeed, after a lo[ng] period of operation, which saw a co[n]siderable population in the immedia[te] vicinity of the furnace, the forest h[as] again closed in around the ruin to r[e]create in part the wild scene that mu[st] have faced the hardy proprietors.

One must confess respect for the cle[v]er workmanship of the men who bui[lt] the Franconia Furnace. Almost perfect[ly] preserved after more than 150 years [in] a climate little more genial than that [of] the Arctic, the blast stack stands 35 fe[et] high, with a diameter of some 20 feet [at] the base. Sheetlike slabs of the gneiss[ic] granite common to the area were so ca[re]fully fitted by the builders that the enti[re] work gives the visitor an impression [of] monolithic solidarity.

The iron used here was massive ma[g]netite, which occurred in a vein on Ir[on] Mountain, some three miles from t[he] furnace, and which was hauled to t[he] scene of operations by oxcart. An an[al]ysis of the Iron Mountain ore by the st[ate] geologist showed it to be the richest [ore] of its kind discovered in the Unit[ed] States up to the time; it contained m[ore] than 96 per cent iron oxide, with a tr[ace] of the element titanium.

The iron ore, along with limest[one] and charcoal, was trammed to the top [of] the blast stack and dumped into [the] furnace by way of the "throat," or "tun[nel] head." A contemporary diagram of [the] furnace's internal structure, which o[rig]inally appeared in a nineteenth-cent[ury] work of the Frenchman J. B. A. Dum[as] was said by the New Hampshire st[ate]

RLY IRON FURNACE now stands abandoned
White Mountain area of New Hampshire.

ologist of the day to be almost exctly identical in plan to that of the anconia Furnace.

An ordinary charge for the furnace nsisted of 15 bushels of charcoal hich still saturates the soil in the vicity, along with lumps of magnetite d glassy furnace slag; 280 pounds of gnetite; and an unspecified weight limestone, obtained from a nearby arry. Hardwood charcoal cost the iron inders $4.00 per hundred bushels, or 50 for the softwood variety; a year's eration required from 200 to 300 thoud bushels of both kinds. Indeed, a ge number of the local inhabitants m to have made their living burning rcoal in the nearby forest.

The productive capacity of the enterse was about 500 tons of iron a year, st of which was made during the agriturally slack winter season when men the farms in the area could be hired at er wages than at other seasons. Thus, ording to the books, the company d a total of $2,297 in wages and rd for 50 hired men during the win, spring, and early summer of the year 38. For the same period there was a cksmith's bill of $85.00; eight loads clay (probably for lining the ladles h which molten iron was poured into ting-forms) were bought at $1.00 a d; and the use of "flasks and patns" cost $25.00. During this time the nace poured out 730,000 pounds of iron worth two cents a pound, and rly 200,000 pounds of castings, which ught four cents a pound.

MOST of the pig and wrought iron made at the Franconia Furnace nt into farm tools and equipment—ns such as carriage iron, sledges, lirons, chains, and tools. "We now e on hand at the manufactory," read ompany advertisement, "a supply of el of superior quality, both blistered l spring, which we offer to the public

at a reasonable price for cash and most kinds of country produce." (Blister is crude steel.) Here also were produced those huge, black iron kettles, formerly so common in New England, known as "farmers' boilers" or "potash kettles." They were used in earlier days for such rough chores as scalding pigs, making soap, or boiling sap for maple sirup, and the larger sizes, weighing up to a quarter-ton each, were usually suspended by chains between two convenient trees. Produced, too, were various sizes of cast-iron stoves, known in northern New Hampshire as "Franconia stoves."

The books of the company also reveal another interesting point: the "efficiency expert" of modern industry may not, in fact, be quite as modern as we think. In 1810, the youthful company fell on lean times. Crops failed, and farmers' payments on the Franconia line of hollow-ware—kettles, baking pans, pots, and "basons"—were miserably slow. A Mr. Smith appeared, and after taking stock of the situation he informed the directors that, while their master iron founder was drawing three dollars a day, "a good founder may be engaged at 1 dollar per day as a founder, and 1 dollar per day as a fireman." Also, noted Smith, "the labour is overrated by two molders per day, whose wages, boarding, and grog would reduce the cost of 1 ton of cast iron by $1.80." Incidentally, the books showed that only 16 of the steelworkers were entitled to a daily ration of grog, at a cost of $1.50 a day to the company.

At one time there were experiments with a shipment of limonite, of the bog iron variety, as ore for the furnace. The company paid $250 for the shipment. and reported that the results "turned ou unkindly," as also did some experimen tal steelmaking that cost $700.

Toward the middle of the nineteent century, signs pointed toward the in pending doom of the Franconia Furnace The New Hampshire state geologis noted that the proprietors "have much t struggle with now owing to the low pric of foreign iron and to the scarcity money among their home consumers. The Franconia Furnace stayed afloa long enough to produce some iron for th battlefields of the Civil War, but it wa not long before the iron industry con menced to move toward Pennsylvani and the Great Lakes states, where, it wa said, unlimited supplies of coal and lim stone could easily and cheaply be we ded to the hematite of the Mesabi ar Vermilion iron ranges. It was the end f the myriad small furnaces that ha served their young nation so efficientl

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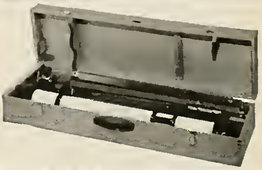

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COVER: The southern toad, *Bufo terrestris*, test predator in a series of mimicry experiments, eyes insects that figured in the investigation. They are, from left: a dragonfly, honeybee, robberfly, mealworm, honeybee, dragonfly, dronefly, and two bumblebees. Mimicry refers to superficial resemblance between members of unrelated groups of animals, demonstrated in robberfly-bumblebee and dronefly-honeybee similarities. Dr. Lincoln P. Brower and his wife, Dr. Jane Van Zandt Brower, discuss their experiments, which were supported by a National Science Foundation grant, in the story starting on page 8. Cover photo is by Lee Boltin.

The American Museum is open to the public without charge every day during the year. Your support, through membership and contributions, helps make this possible. The Museum is equally in need of support for all of its work in the fields of research, education, and exhibition.

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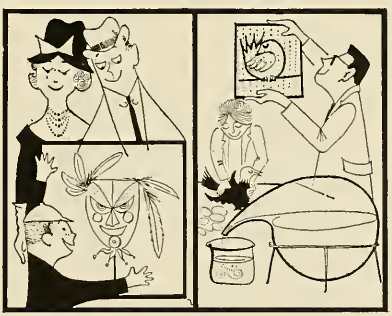
MUSEUM MEMO

Members of The American Museum of Natural History come from almost every part of the globe. There are nearly 120,000 of them, mostly Associates, and they live in New Zealand, Australia, Europe, Africa, South America, the islands of the Pacific, and there is one lone Associate in Sarawak. Those in the United States are found mainly outside the metropolitan area of New York City.

Their interest in the natural sciences has led to many diverting hobbies, to recreation, relaxation, and even to vocations. They have extended that interest by lending their financial support to Museum activities, and their dues help support research, exhibition, scientific and popular publications, expeditions, and adult and child education.

We like to think that our 120,000 Members throughout the world are extensions of the American Museum itself. This is important, because the Museum is more than a treasure-trove of the rare, the exotic, the bizarre, or the unusual. It is a great teacher that can tell us what happened in the past, what exists in the present, and what the future may hold, depending on our own interests.

It meets the needs of the student, the child, the farmer, the housewife, the industrialist, the artist, and the teacher. Each finds, among its many offerings, an awareness of daily living plus an appreciation of his own place and the place of his neighbor in an increasingly complex and interrelated world.



Our interest in the natural sciences is, no more and no less, an interest in our environment. The first living thing was affected by its environment and affected it in turn. So today is man. He is but one of many species of animals — and he is no more necessary to the continuance of life on this earth than were the dinosaurs, the dodoes, or the passenger pigeons. Our very existence in the future may depend upon our understanding of this fact and of the world in which we find ourselves.

We are a part of nature, although we control much on this earth. We are still subject to great basic laws and forces that limit and restrain us within definite boundaries. Were our climate to change from temperate to glacial cold, our works might be wiped out over most of the globe.

Even more important to us than great earth changes are the difficulties we make for ourselves by not understanding the consequences of our acts. The intelligence and reason on which we so pride ourselves create needs and desires that were not shared by our primitive ancestors.

In the satisfaction of these needs and desires. we lay waste to our great forest resources, deplete and mine our soil, use up irreplaceable resources, plow the plain, and sow the dust bowl, and sometimes conduct ourselves as though we were to be the last generation that would ever inhabit this earth.

Science museums in general—and the American Museum in particular—have long been aware of the need to acquaint our people with the problems of soil, water, mineral, wildlife conservation, and of the conservation of man himself. The American Museum's scientist-educators have expressed their concern in their research, their writings, their teaching, and in their exhibits; the Department of Education instructs hundreds of thousands of children every year; and radio and television have increased our audience to astronomical numbers of eager young people.

Someone once said, "A strong and interested Membership is one of a museum's greatest assets." This is true in at least two ways. The membership acts as a great emissary of the institution, carrying its message wherever it goes. It also provides much of the financial support that enables the Museum to fulfill its obligations to the public.

There are ways in which present Membership can be of even more assistance to the Museum. For instance, it is upon Associate Memberships that higher categories are structured. The Associate Member who becomes an Annual Member increases his aid to the Museum by 200 per cent. Those who convert to even higher categories, such as Family or Life Membership, are proportionately, of course, of even greater help.

Because the Museum—a great center of free education —*is* free. it requires and deserves public support. You can help by persuading other people to become Members; by raising your own Membership to a higher category; by remembering the Museum through gifts or bequests.

In all of these, your enthusiasm is the guiding principle. Such enthusiasm is not only transferable to friends who may not be aware of the Museum's work and its place in the community: it can also stimulate your own special interests. adding to the Museum's meaning every year.

William A. Burns
Membership Chairman

Reviews

A wide world of birds

By Wesley E. Lanyon

Birds of the World, by Oliver L. Austin, Jr. *Golden Press, $14.95; 316 pp., illus.* by Arthur Singer. Birds of the Caribbean, by Robert Porter Allen. *The Viking Press, $15.00; 256 pp., illus., 98 plates.* The Book of Bird Life, by Arthur A. Allen. *$9.75; 396 pp., illus.* Bird Study, by Andrew J. Berger. *John Wiley & Sons, $9.00; 389 pp., illus.* Bird, by Lois and Louis Darling. *Houghton Mifflin Co., $5.00; 261 pp., illus.*

A logical corollary of man's progress in shrinking this wide, wide world is his growing fascination with and appreciation of birds. Increased travel has led to increased interest in birds of far-off places—birds that constitute an almost endless variety of beauty, shapes, and habits—and questions naturally arise as to how they compare with the birds back home. Ornithologists have not been oblivious of this variety, but they have been tardy in sharing their knowledge with that most elusive of all creatures—the "educated layman."

In 1958, E. Thomas Gilliard, Associate Curator of Ornithology at The American Museum of Natural History, authored the first comprehensive English language volume on birds of the world since Knowlton and Ridgway's book, published in 1909. Now another volume has appeared—the truly spectacular *Birds of the World*, by Oliver L. Austin, Jr., illustrated with paintings by Arthur Singer. This book, like Gilliard's, helps to fill the half-century vacuum in readily available information on the world's bird life.

Dr. Austin, well-known ornithologist of the Florida State Museum, has compiled an amazing encyclopedia of information on the vast array of birds of the world, written in a most delightful, yet scholarly, style. An introduction presents a brief discussion of how birds are related to other animals, how they have evolved through geological time, and how they are presently distributed throughout the world. The remainder of the text is devoted to descriptions of the birds and their habits, and there is a list of selected references for anyone who may be interested in further information about specific areas of the world. The author has, of necessity, relied heavily upon the scientific reports of a great many ornithologists. A bibliography includes the titles of a large number of these original sources. A helpfu[l] index to scientific and common names in the text and illustrations is included.

One hundred and fifty-five families o[f] birds receive treatments varying in length from a quarter of a page for the smaller families, to three to four pages for the larger ones (Icteridae, Fringillidae, and Ploceidae). Each of the family accounts gives size of the family (number of species), general distribution, derivation of the group name fossil history (insofar as known), diagnostic family characters, and general habits. Additional information about the larger families, the outstanding genera and better-known species is presented together with continental range maps for some of the more primitive families. Austin's arrangement of the families of birds follows that of the American school, terminating with the sparrows and finches. There are two notable departures from this conventional order. The honeycreepers of the New World tropics, generally treated as a separate family, are here considered in part with the wood warblers and in part with the tanagers, following the recommendations of Beecher and Tordoff. The carduelinе finches (including goldfinches crossbills, etc.) are included with the Ploceidae (an Old World family of weaver finches, etc.).

Over 700 species of birds are illustrated in color by Arthur Singer. Mr. Singer is not an ornithologist, and hence stands conspicuously alone among most of his contemporaries who have made names for themselves as bird artists. It is remarkable that he has captured the appropriate postures and actions of so many of his subjects without the benefit of the field experience and knowledge generally required for such refinements. The arrangements of Singer's birds on the pages are a refreshing artistic element, but, though the treatment is novel and lends variety to the book's format, it may lead to some confusion. For example, on the first page of text devoted to the manakins, one finds paintings of four cotingas. And there are discrepancies in the relative sizes of birds within the same plate, as for instance, the northern royal flycatcher and the wood pewee, and the

arred cuckoo-shrike and its compan-
ns. The 300 plates must have been ainted over a period of years, and the rtist's progress can be followed from me rather mediocre initial renderings later ones that are just a few feathers hort of being magnificent. The color and eproductions are generally excellent.

Perhaps my most stringent criticism f this book is directed toward the reparation and editing of the caption aterial. It is lamentable that such a su- erb volume should be marred by innum- rable misidentifications, typographical rrors, and inconsistencies. All illus- rations should have been checked and ouble-checked against a comprehensive useum collection to assure accurate lentifications of the species actually epicted. For instance, the red-fronted hornbill *(Phacellodomus rufifrons)* is ctually a spinetail *(Synallaxis)*; the ed-breasted blackbird designated as *Pezites militaris* is actually *Leistes mili- aris*, a totally different bird in appear- nce; the bird called a green-winged eal *(Anas carolinensis)* is, in fact, a ommon teal *(Anas crecca)*; and these re only a few of such errors.

Bird watchers will surely find *Birds f the World* informative, entertaining, nd delightful reading. The book will lso be in demand for its art work alone, o be displayed as a collector's item in iving rooms and libraries around the world. And despite some shortcomings, he volume is certain to be in reference ibraries of professional ornithologists.

A substantial part of the recent increase in tourist travel, and its associated interest in the bird life of exotic places, has involved the West Indies and the lands bordering upon the Caribbean Sea. Ten years ago, the Alcoa Steamship Company inaugurated a series of books on the natural history of the area. The first volume, published in 1951, deals with flowering trees, and the recently published *Birds of the Caribbean*, by Robert Porter Allen is the second volume of the series. The delimitation of the area treated by this book is a matter of political and economic expediency on the part of the sponsor. It cannot be justified on zoogeographical grounds, for the area has no unique avifauna, but is instead a melting pot for the birds of the West Indies, North America, and tropical Central and South America. Consequently, even the author has difficulty defining the region.

There is a cursory discussion of the origin of Caribbean birds and the history of bird study in the area, but most of the book consists of Allen's species accounts, averaging one page in length and containing notes on habits, local legends, conservation, the author's field experiences, and quotes from writings of other ornithologists (Wetmore, Bond, Skutch, Chapman, and others).

The book contains 98 colored photographs taken by 23 photographers. However, approximately one-third of the photographs are of captive birds in zoological parks and aviaries; one-third are of wild birds taken outside the Caribbean region, in places such as England, Spain, Tennessee, New Jersey, and California; and the remaining third are of wild birds within the defined area. This emphasizes the author's lament that good photographs of Caribbean birds are hard to come by. The reproduction is generally poor, with blues and greens overemphasized. Bird watchers, for example, will find the photos of the roadside hawk *(Buteo magnirostris)* and of the bare-eyed thrush *(Turdus nudigenis)* terribly misleading, for these birds simply do not exist as illustrated.

The beautiful one and one-half page photograph labeled the purple-throated fruitcrow *(Querula purpurata)* is actually a photo of the red-ruffed or scutated fruitcrow *(Pyroderus scutatus)*, a bird of altogether different appearance. The bellbird illustrated is not *Procnias alba*, but rather *Procnias nudicollis*. Likewise, the pictured cock-of-the-rock is the Andean species, *Rupicola peruviana*, not the native *Rupicola rupicola*.

Some of the photographs are unfortunate selections if they are meant to represent the most typical birds of the "Caribbean region." The black phoebe *(Sayornis nigricans)* enters the tropical countries of Central and South America primarily as a mountain bird, beyond the "influence of the Caribbean." This photograph, incidentally, was taken in California. The chestnut-bellied chlorophonia *(Chlorophonia pyrrhophrys)* is best-known as an Andean bird, and the photograph was taken at New York's Bronx Zoo. Numerous other photographs that are extremely mediocre for a book of this design (and price) include those of the scarlet ibis; the smooth-billed ani perched on some barbed wire in Cuba; and the badly blurred meadowlark photographed from a car window in Florida.

To summarize, *Birds of the Caribbean* is outpriced, in spite of a subsidy, completely disregards quality of reproduction and selection of photographs, and is a poor consumer investment.

Among the multitude of published bird books, comparatively few have aimed at educating the public in the biology of birds. It is a far easier task for an author to relate his experiences on some birding jaunt, to assemble a series of photographs (for which there appears to be an infinite market, regardless of quality), to attempt a new twist on an

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DR. LANYON, with THE AMERICAN MUSEUM's Ornithology Department, regularly contributes to these pages.

old identification guide, or to do a rehash of the "birds in our garden" approach. Arthur A. Allen of Cornell University, who is generally considered the first professor of ornithology in this country, has dedicated his life to educating both students and the public in bird biology. The first edition of his *Book of Bird Life* was published in 1930. Since then there have been eleven reprintings, and a second edition was published in April, 1961. Most of the material that appears in *The Book of Bird Life* was originally published in essay form for the high school student and the "intelligent bird watcher." It is not a college textbook, nor was it intended to be.

The format and content of this edition differs little from its predecessor. The one "new" chapter consists in part of an eight-page discussion of the ethological approach to the study of bird behavior, and in part of material that has simply been relocated from another section of the first edition. Seventy-three new figures by William Dilger, illustrating the diagnostic characters of the families of North American birds, represent the major innovations. The illustrations are a considerable improvement over those in the first edition, although the colored photographs are poorly reproduced and ineffectively small. Additional literature references are included. Not all of the text has been brought in line with recent research, however, as proved by the retention of the statement that *Ichthyornis* (a fossil Cretaceous bird) had teeth. The statement that the bluebird is the only species that has been raised in isolation "to the singing age" is also in error, for German scientists worked successfully with several species prior to the Cornell bluebird studies.

Although some minor revisions have been made in the text, there has been little attempt to incorporate some really new avian biology material—material that the "intelligent bird watcher" would find fascinating. Examples are the recent developments in studies of orientation and navigation of birds, and investigations into the owl's incredible ability to hunt its prey in total darkness via auditory cues. Oddly enough, these studies were established, in part, by research carried out in Dr. Allen's own laboratory. In spite of falling short of its potentialities, however, *The Book of Bird Life* is still a classic.

A somewhat different approach to the popularization of bird biology has been used by Lois and Louis Darling. In *Bird*, co-authored and illustrated by this husband and wife team, emphasis has been placed upon the biological attributes of birds rather than upon the techniques used in observing and attracting them. No doubt some readers will object to the emphasis placed upon such topics as anatomy and physiology. The authors obviously intend to provide information that is not readily available in popular form, and this they have done in a most entertaining, yet authoritative, manner. Additional chapters are devoted to evolution, behavior, and migration.

By relying principally upon review articles and textbooks for much of their information, the Darlings have missed some of the investigations that have yet to be reported upon in those sources—such as the discovery that the hormone prolactin is not the principal factor in initiating incubation in at least some birds. These oversights appear to be few in number, however, and the text reflects a fine review of ornithological literature. This book deserves a good reception.

When publication of Andrew J. Berger's *Bird Study* was announced, there was hope that the volume might fill the need for a really first-class ornithology text. The book is ostensibly designed to stress the basic principles and concepts of ornithology for the student of a liberal arts curriculum, using, for the most part, North American birds as exemplary material. In view of this avowed aim, the omission of certain information and the inclusion of other material is somewhat paradoxical. Nowhere, for example, are there discussions of how the study of ornithology is pursued today, either on the amateur or the professional level, or of professional opportunities in the field, should a liberal arts student be smitten by the glamour of the science. Essentially nothing is said about the origin and evolution of birds. Inadequate attention is paid to food habits and the economic relationships of birds and man.

By way of contrast to these omissions of what could be regarded as the "introductory" aspects of the science, Dr. Berger leads his liberal arts students into concern for the strictly theoretical concepts of behavior (consummatory acts, appetitive behavior, redirection activities, etc.). He also stresses consideration of the philosophy (political and sociological) of the conservation movement in this country, which strikes me as being well outside the scope of an introductory science text. I also question the pedagogic wisdom of using innuendoes and out-of-context quotations to establish basic principles of any field.

Some of the chapters in *Bird Study* are well done. In discussing migration, for example, Berger has considered the various aspects (origin, description, annual stimulus, navigation, lunar and radar studies) in a logical and sensible balance. The chapters on song and on anatomy also cover their areas adequately and yet are not too technical for the beginning student. Numerous general references are given for the student who may wish to pursue a given topic.

Robberfly is mimic of the bumblebee and is often found where bees abound

Bumblebee is model for robberfly, which bears strong resemblance to bee.

By Lincoln P. Brower and

Investigations

Just one hundred years ago, the great English naturalist H. W. Bates published a classical paper interpreting some of the observations he had made on mimicry in tropical American butterflies, which was based on eleven years of research in the Amazon Valley. He presented his report to the Linnaean Society of London, and within a short time, mimicry became a key support of the theory of evolution by natural selection, which Charles Darwin and Alfred Russel Wallace had outlined to the society three years earlier, in 1858.

Bates had returned to England from South America with vast collections consisting of individuals of nearly 15,-000 species, no less than 8,000 of which were then new to science. Con-

DRONEFLY, another mimic, resembles honeybee in color and feeding habits.

HONEYBEE feeds at a composite flower like that on which its mimic is shown.

NE VAN ZANDT BROWER

Into Mimicry

nplating the facts he had gathered, ites saw that his observations conned unique evidence in support of irwin's and Wallace's new theory. s own hypothesis concerned mimetic alogies, which were, in the natural-'s own words, "resemblances in exnal appearance, shapes, and colours tween members of widely distinct milies. . . ."

His idea of mimicry was based particularly on the tropical butterflies of the family Heliconiidae. In South America he had noticed that among the myriad insects these common butterflies with brilliant coloration and slow, conspicuous flight were never eaten by the abundant birds and lizards of the jungle. Surprisingly, other butterflies of a second, quite un-

Anesthetizing bumblebee with carbon dioxide is done in field near Archbold Biological Station, where experiments in efficacy of mimicry were performed.

related family appeared superficially identical to the Heliconiids. To explain this curious relationship, Bates proposed that the common Heliconiids were distasteful to insect-eating vertebrate predators. Upon trying one. Bates postulated, a bird would find it unpleasant and would reject it. The bird would then remember this bad experience, and when encountering the butterfly's bright color pattern again would refuse the insect on sight. Now, if a palatable species looked like a common, distasteful one, the predator would mistake the palatable butterfly for the unpalatable insect. Thus, a palatable butterfly could, by deception, escape being eaten. Such a deceptor is called the mimic, and the distasteful species it resembles is termed the model. Bates also discovered that the mimic is much rarer than the model. This is reasonable because, in learning what is good to eat, birds would most often attack the common model, and so learn quickly that its color pattern was associated with an unpleasant taste. Mimicry would thus be effective.

The question of whether or not vertebrate predators, and especially birds, really do eat butterflies became a subject of controversy among naturalists, because neither ornithologists nor entomologists had recorded many observations of birds attacking these insects in nature. Two camps developed. One stated flatly that birds never eat butterflies, that any similarities in appearance of unrelated butterfly species are due to chance. and that mimicry is a figment of man's imagination. The proponents of mimicry countered this argument by gathering extensive observations, particularly in the Tropics, where some kinds of birds feed heavily on butterflies during certain seasons of the year. These men also found that model butterflies they had caught in their nets often bore V-shaped notches in their wings or V-shaped scars where the powdery scales normally covering the wings had been removed. It was soon discovered that birds sometimes chased and snapped at other individuals belonging to the model butterflies' species, but then let them go. And when these butterflies were caught, it became clear immediately that the torn or rubbed areas on the wings were caused by the birds' beaks. The beak marks, besides showing that birds do attack butterflies, also provided indirect evidence

)rs. L. and J. Brower, of Amherst
College, are respectively Assistant
Professor and Research Associate in
he biology department. Lee Boltin
photographed their work in the field.

d t the models were unpalatable: they vere tried but then rejected. Moreover, ent experiments by H.B.D. Kettle-vell, in England, have shown conclu-sely that birds prey heavily on s·cies of moths that had rarely been s n to be eaten by birds. Similarly, the past two years we have observed a ock of red-winged blackbirds, *Age-laus phoeniceus* (Linné), catching and vouring many large swallowtail tterflies in a swamp in south central rida. These findings that birds do Lepidoptera in nature point to the nger of drawing false conclusions sed on insufficient observations.

Shortly after the turn of the cen-y, some observers attempted to per-m experiments with caged preda-s, including birds, lizards, and nkeys, to which model butterflies re offered. Almost invariably, the ightly colored models proved to be palatable. Without doubt, the great-co-ordinator of these observational dies of mimicry was Sir Edward ulton, for many years Hope Profes-r at Oxford University in England. was Poulton who, while lecturing 1909 to the Entomological Society America, drew attention to three atively simple instances of mimicry ong North American butterflies, e of which will be described below, d pointed out the opportunities for search they offered. For in spite of vast literature about observational dies, actual experimental evidence r the existence of mimicry was strik-gly inadequate, as A. E. Emerson, e famous American ecologist, em-asized as recently as 1949.

As though the lack of conclusive experimental evidence for mim-ry were not enough of a problem, the ry origin of mimicry puzzled scien-ts at first. While Bates' hypothesis fered an explanation of the incredi-e resemblances between a number of sects, considerable time passed be-re the mechanisms of the early olution of mimicry began to be derstood. As mentioned previously, mimic appears superficially to re-mble its model, but in fact the two e not closely related. When a mimic utterfly is examined in detail, the reful observer can see that in char-

Stinging apparatus of bumblebee is removed. Bees so treated were offered to control toads to see if bees, made harmless, would be acceptable as food.

All insects were strung with needle and lengths of 50-gauge, gray cotton thread. They could then be presented to toad predators in a uniform manner.

PALATABLE DRAGONFLY **is presented to toad, which seizes it, in bumblebee-robberfly mimicry experiments. By eating dragonfly, toad manifests hunger. Thus, when hungry toa rejects a different insect, lack of appetite is not the caus**

acteristics such as the number and the arrangement of wing veins, the structure of the legs, or the sexual organs, it is like other members of its own family and not like the model butterfly at all. How, then, does it happen that in color pattern alone the mimic is altered so as to differ radically from its relatives and resemble the model? This can be explained by reference to a well-known example of mimicry in the North American butterflies. The familiar monarch and viceroy frequent summer gardens throughout the eastern United States, and related pairs of butterflies occur in Florida and in the Southwest. The monarch, *Danaus plexippus* (Linné), is the model, and it is known from experimental studies to be distasteful to some birds, such as the Florida scrub jay, *Aphelocoma coerulescens coerulescens* (Bosc). The viceroy, *Limenitis archippus archippus* (Cramer), is the palatable mimic. Both model and mimic are orange in ground color with black and white markings, and look remarkably alike. However, the viceroy's non-mimicking relatives are all basically blue-black in color. They include several species of *Limenitis* from the Northeast, the Rocky Mountain states, and the Far West. Because of the prevalence of blue-black coloration among the viceroy's relatives, it is considered the ancestral shade of the viceroy. The problem, then, is to account for a change in the viceroy from its probable original dark color to its present orange, mimetic coloration, which resembles the monarch's.

THE study of heredity has disclosed that spontaneous, heritable changes called mutations occur in the germ plasm of all living things. These mutations may result in visible differences in characteristics, such as the color pattern of a butterfly's wing. Knowing this, one can start with the presumably dark viceroys, and reconstruct the manner in which their orange coloration has theoretically evolved. Suppose among the dark ancestral viceroys a few slightly orange individuals arose through mutation. These, along with the commoner, blue-black ones, would both make up the viceroy population. Now, if an experienced predator that had learned to avoid orange-colored monarchs were to come upon these viceroys, it would be more likely to eat the blue-black form of the viceroy than it would the pale orange one, because even a hint of orange would remind the predator of the distasteful monarch. Thus, more of the new, orange variant viceroys would survive to produce offspring than would the blue-black form, even though the sum total of individuals of both forms would be the same in each new generation. If we extend this situation by imagining not just one mutation for pale orange, but rather a series of small color and pattern changes occurring at intervals during a very long period of time, it can be seen that through the agenc of discriminating predators, the col variant of the viceroy most like tl unpalatable model would tend alwa to prevail. In this way, apparently, tl present, orange viceroy, so like tl monarch, has gradually evolved.

Butterflies belonging to the inse order Lepidoptera were the subje of Bates' classical theory. There a numerous other instances of strikin resemblances between different kin of insects. For example, many be (Hymenoptera), noxious because their stings, are models for harmle flies (Diptera) that look, act, and eve sound very much like bees.

While conducting our research pr gram in south central Florida at tl Archbold Biological Station, we b came interested in two instances mimicry involving bees and their fl mimics. The first concerns tl bumblebee, *Bombus americanoru* (Fabricius), which is mimicked by robberfly, *Mallophora bomboid* (Weidemann). The two insects a seen together quite frequently in fiel where blooming plants of the pea fan ily are found. Like the bee, the ro berfly has a black and light col pattern, a plump, fuzzy body, an hairy legs. On the third pair of le it even has two patches of light hai that simulate the pollen baskets of tl bumblebee. The second model-mim pair that we studied is the honeybe *Apis mellifera* Linné, and the dronefl *Eristalis vinetorum* (Fabricius). Tl

Same toad is subsequently offered robberfly. Toad reacts by consuming it, thereby indicating that the toad does not yet associate the harmless robberfly with the similar but noxious bumblebee, and that robberfly is palatable to toad.

dronefly has a narrow, black marking along the middle of its back that creates the impression of the honeybee's "wasp-waist." The dronefly also has beelike yellow and black rings girdling its abdomen. The buzzing of the dronefly, as well as its habit of feeding along with honeybees at certain composite flowers, make it a very convincing mimic of the honeybee to the human observer.

We wanted to know if this similarity is also confusing to insect-eating predators. Are the bee models really noxious? Is it the sting that makes them so? And what will happen when a predator that has encountered a bee is then given a harmless fly mimic? In order to test the effectiveness of mimicry of the bumblebee and of the honeybee, we carried out laboratory experiments in which caged toads, *Bufo terrestris* (Bonnaterre), were used as predators. Known as the southern toad, this animal was a particularly good subject because it is a common insect eater in the southeastern United States and is abundant in the vicinity of the Archbold Biological Station, where we caught them for our experiments. The toads were taken to the laboratory and were confined singly in cubic cages twelve inches on a side. The bottom and back of each cage was made of plywood, the two sides and front of gray plastic screening, and the top was a removable piece of glass that allowed access to the inside. Cardboard partitions separated the cages so that the toads could not see one another, thus precluding the possibility that the behavior of one might influence another visually. Each cage was equipped with a three-quarter-inch-deep water dish.

In preparation for each day's test, which was conducted in the evening when the toads were naturally active, bumblebees and robberflies or honeybees and droneflies were collected in fields near the Archbold Station. They were stored in a cold room until needed, and then were anesthetized lightly with carbon dioxide so they could be handled easily and prepared for presentation to the toads. In addition to the models and mimics, we also needed edible insects that we knew were acceptable to toads. By presenting these insects to the toads, we could make certain that the animals were hungry enough to eat palatable insect food, even if they should reject a model or mimic. For the bumblebee-robberfly experiments we used large dragonflies, *Pachydiplax longipennis* (Burmeister), as edible insects, and for the honeybee-dronefly tests we gave the toads beetle larvae, called mealworms, *Tenebrio molitor* Linné, which have approximately the same bulk as the models and mimics.

After trying many different methods of presenting the insects to the toads, we finally settled upon a technique that proved very satisfactory. Toads will eat food only if it moves. To standardize the motion of the insects, each was strung with a fine needle and 50-gauge, gray cotton thread so that it could be suspended and moved in front of a toad, to be seized or rejected. The animal had thirty seconds to eat each food item lowered into its cage. If the food was not eaten, the thread was pulled up, withdrawing the insect. During an experiment, model, mimic, and edible insects were presented in such an order that the toad could not learn to anticipate what was coming next. A sample random sequence for two successive days in the bumblee experiment was as follows: edible, model; mimic, edible/mimic, edible; model, edible.

The experiments on the bumblebee-robberfly complex were conducted with six toads. Of these, three were experimental animals and three were control animals. The experimental toads were given ten live bumblebees and ten dragonflies, singly, at the rate of four insects a day. At first, each readily seized a bumblebee, but in so doing was severely stung on the tongue and roof of the mouth. The toad reacted by making violent movements with its tongue, by blinking, by listing toward the side of the injury, by puffing up the body, and by ducking the head, which produced a generally flattened appearance. After one or two such experiences, the three experimental toads learned that bumblebees were noxious and they would not strike at the others that were offered. They

TWO TYPICAL TOADS' REACTIONS IN HONEYBEE-DRONEFLY TESTS

	Successive Insects Presented	Experimental toad (Live honeybees with stinging apparatus intact)	Control toad (Dead honeybees with stinging apparatus removed)
First Day	Mealworm	Eaten	Eaten
	Dronefly	Eaten	Eaten
	Dronefly	Eaten	Eaten
	Mealworm	Eaten	Eaten
	Honeybee	Eaten-Stung	Eaten
	Mealworm	Eaten	Eaten
	Mealworm	Eaten	Eaten
	Honeybee	Rejected	Eaten
Second Day	Honeybee	Eaten-Stung	Eaten
	Mealworm	Eaten	Eaten
	Mealworm	Eaten	Eaten
	Honeybee	Rejected	Eaten
	Honeybee	Rejected	Eaten
	Mealworm	Eaten	Eaten
	Dronefly	Rejected	Eaten
	Mealworm	Eaten	Eaten

TEST RESPONSES of both experimental and control toads are listed in table.

LIVE BUMBLEBEE, capable of stinging, is presented to the experimental toad.

consistently ate the dragonflies, however, showing that they could distinguish between noxious and edible insects. The crucial part of the experiment was the substitution of robberfly mimics for bumblebees. Would the toads eat the flies, or would they confuse them with the bumblebees and reject them? Of the thirty robberflies that were presented to the three experimental toads, only one robberfly (3 per cent) was eaten.

MEANWHILE, the three control toads were playing a key role in the experiments. They were used to determine the actual edibility of the robberfly mimic. These toads were never exposed to the sting of a bumblebee. They were offered only robberflies and dragonflies. What were their reactions to the mimic? Two of the three ate the robberfly readily every time it was presented. The third toad was bumped in the face by the first robberfly it was given. This experience seemingly affected the toad, since it subsequently rejected all mimics, although,

Toad leaps to swallow the bumblebee and is severely stung on tongue. Among its reactions were violent movement of tongue, ducking, and puffing body.

umbers of Experimental Toads (fed intact, ve Honeybees) and Control Toads (fed dead oneybees, with stinging apparatus removed) ating and rejecting a final Dronefly Mimic.

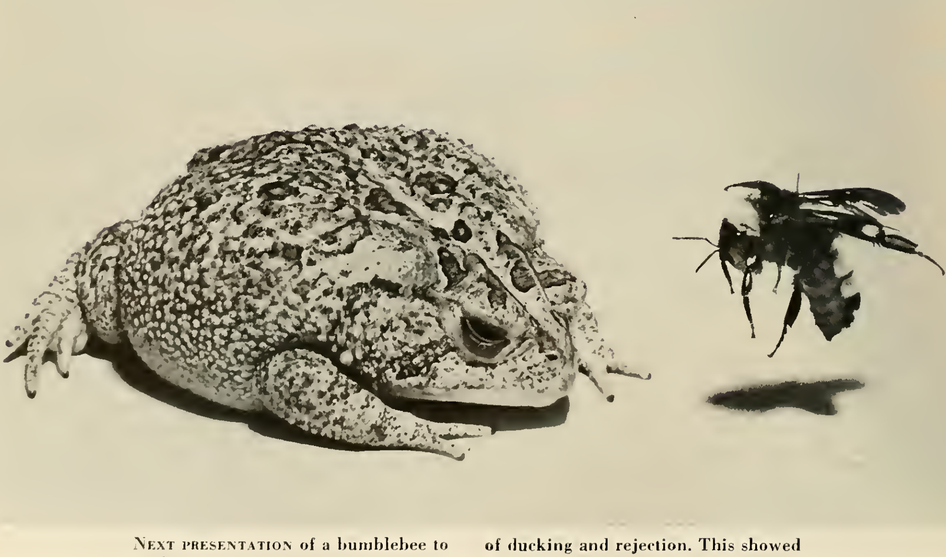
	Experimental Toads	Control Toads	Total
te nal imic	9 [illegible]	19 [illegible]	28
ejected nal imic	13 [illegible]	3 [illegible]	16
otals	22 [illegible]	22 [illegible]	44

like the other two controls, it ate all the dragonflies. To summarize, then, of the fifty-one robberflies presented to the control toads. thirty-four (67 per cent) were eaten.

One further aspect of mimicry remained to be tested. Was the sting really the source of the bumblebee's noxiousness? It is quite easy—with the aid of a dissecting microscope and fine watchmaker's forceps—to remove a bee's stinging mechanism. First the bee is anesthetized with carbon dioxide. Then it is placed on its back on the stage of the microscope. The abdomen is pressed carefully with the forefinger, which causes the sharp point of the stinger to protrude. This is grasped with the forceps. and the whole stinging apparatus and the sac containing the liquid poison is pulled out. Thirty-six bumblebees were prepared in this way and were then presented to the three control toads. Twenty-four of the harmless bumblebees were eaten by the two toads that had eaten robberflies. The third toad, which had been bumped by the robberfly, rejected the twelve operated bumblebees presented to it. These results told us two things: first, that the sting was the source of noxiousness in bumblebees, and second. that a toad that refused robberflies would also reject bumblebees. This indicated that toads fail to distinguish between bumblebee models and robberfly mimics.

If we now look at the results of this experiment as a whole, we can reach several conclusions that answer the initial questions we set out to test. The experimental toads showed us that live bumblebees were highly noxious to them and that toads, after being stung, could learn to reject bumblebees on sight. When the robberfly mimic was offered instead of a bee, the toads also refused the mimic. However, two control toads that never experienced bumblebees ate robberflies readily. Therefore. we concluded that the rejection of the robberfly by the experimental toads could be attributed to mimicry. These toads apparently learned that the bumblebee's color pattern was associated with the noxious sting and confused the robberfly's coloration with that of the bumblebee. Mimicry was thus shown to be effective.

A second experiment was performed with honeybee models and their dronefly mimics. A large number of toads served as caged predators. We wanted to be able to compare the reactions of toads that ate mimics freely at the beginning of the experiment with the same toads' reactions to mimics after experiencing the model.



Next presentation of a bumblebee to toad evokes negative reaction in form of ducking and rejection. This showed that toad had learned bee was noxious.

In order to do this, it was necessary for each toad to pass a qualification test before being allowed to participate in the experiment: each had to begin by eating mimics as well as the edible mealworms. Of the sixty-seven toads that were brought in from the wild and tested, forty-four qualified. The other twenty-three did not, because they failed to eat mealworms or droneflies, or both. Fourteen of this group ate their mealworms but refused the first dronefly, and some also exhibited a reaction of rejection to the droneflies by ducking and puffing up. Without further experiments it is not possible to say conclusively why the toads rejected the initial mimics. However, their behavior suggested strongly that these animals were already agents in mimicry: that the toads had had experience with honeybees before being caught, and when they were confronted with mimics in the laboratory, they confused the two. This is possibly a valid conclusion, because all fourteen of the toads ate the mealworms, which shows that they were discriminating between the food items offered, and were not simply rejecting everything.

In addition to the qualification test to select only those toads that would initially eat the mimics, a second precaution was taken to insure that only visual mimicry was involved in the investigation. All the droneflies were killed by deep-freezing before they were presented to the toads. In this way, we eliminated the possibility that auditory mimicry, caused by the similarity of the buzz of the dronefly mimic and the honeybee model, might influence the toads' reactions. To begin the experiment, the forty-four qualified toads were divided into two groups: half were designated as experimental subjects, and the others as controls. The experimental animals were given a series of five live honeybees and five mealworms. The control toads were given five dead honeybees from which the stinging apparatus had been removed, and five mealworms. These bees had also been killed by deep-freezing to eliminate their buzzing, which in itself might have caused the controls to reject them. The order in which the insects were presented to all the toads in both groups and the reactions of a typical control toad and a typical experimental toad are shown in the table on page 14, *upper left*.

The experiments showed that the live honeybees did indeed sting the experimental toads, although apparently not as severely as the larger bumblebees had stung the toads in the other tests. A few of the toads ate the live honeybees without evident discomfort, but most, after receiving two or three stings, rejected the honeybees on sight. The control toads, for the most part, readily ate their frozen bees from which the stinging mechanism had been removed. This shows that the sting of the honeybee, perhaps reinforced by its buzzing, accounts for its rejection as food by the experimental toads. Both groups of toads continued to eat mealworms throughout the experiment. This indicates that the experimental toads that rejected the bees actually had learned to tell the difference between the two. In the final test, both the controls and the experimentals were given a last dronefly mimic, followed by a final mealworm. All forty-four toads ate the mealworm, which indicates that they accepted in-

EFFECTIVE MIMICRY is demonstrated when the toad also rejects previously acceptable robberfly, which it seems to confuse with the stinging bumblebee.

Dangling dragonfly before the toad was means of testing toad's ability to discriminate between insects that were harmless and those that were harmful.

sect food readily to the end of the experiment. The vital question is: did more control toads than experimental toads eat the last dronefly mimic? The results are summarized in the table on page 16, which shows that there was a striking difference between the reactions of the two groups of toads. Nearly all (86 per cent) of the control toads ate the final dronefly, whereas less than half (41 per cent) of the experimental toads ate their last dronefly. We can conclude that the experience of the experimental toads with live honeybees greatly reduced the likelihood that they would eat the dronefly mimics. To a large degree the noxious model did protect the mimic from being eaten. The experiment, therefore, offered strong evidence in favor of Bates' theory. The final, essential support, so long overlooked by naturalists, depended again upon the control toads. By eating the droneflies at the beginning and end of the experiment, they proved that the dronefly was palatable, and was thus a true, visual, Batesian mimic.

It is interesting to compare the results of the honeybee-dronefly experiments with those of the bumblebee-robberfly tests. Were the two models equally noxious? Were the mimics in each instance protected to the same extent from being eaten by the toads? The results showed that the three experimental toads attacked a total of nine out of fifty-one bumblebees (18 per cent), whereas in the experiments with honeybees, the twenty-two experimental toads seized seventy-seven out of one hundred and ten (70 per cent). This indicated that the bumblebee is more noxious to toads than is the honeybee, because fewer trials were needed to teach the toads to reject the former on sight. This is undoubtedly attributable, in part, to the bumblebees' being larger and possessing more toxic substance than do honeybees. In addition, bumblebees can inject the poisonous fluid into an attacker repeatedly, while honeybees can sting only once. Was this difference also reflected in the percentage of mimics eaten by the experimental toads in the two experiments? The results indicated that it was: only two out of a total of thirty robberflies (7 per cent) were attacked; however, nine out of twenty-two droneflies (41 per cent) were seized. These results fit one part of the mimicry theory very nicely. Students of natural selection have reasoned that the more noxious the model, the more protected the mimic would be from predation. The bumblebee and honeybee appear to exemplify, for the first time, a situation in which two levels of noxiousness do confer differing degrees of immunity to attack by toads.

These experiments are only the beginning of a vast amount of basic biological research necessary to understand more fully the evolution of mimicry. One particularly interesting but as yet unsolved problem concerns the possibility of an additional reason for the mimicry of the bumblebee by the robberfly. These flies are commonly known as bee killers because they prey on Hymenoptera by preference although if bees are scarce, the flies will eat large beetles, bugs, and grasshoppers. In the course of our field research, we kept records of the kinds of prey that robberflies were seen to attack, and found that the bumblebee was the favorite food of *Mallophora bomboides*, the robberfly that resembles the bumblebee. The manner in which the robberfly seized its prey was precise and swift. It would perch on a stalk in a vertical position about one to three feet from the ground. As a bumblebee rose from feeding at a nearby blossom, the fly rapidly flew to the bee from above and behind it and grasped the dorsum with its long hairy legs. Then the robberfly immediately drew the bumblebee toward its body, inserted its mouthparts into the bee's thorax, and injected a substance that paralyzed the bee almost instantaneously. The fly then returned to a stalk, often the same one from which it had begun the attack, and, in a vertical position once more, proceeded to digest the prey externally by pumping its digestive juices into the bee. This

rased the soft tissues of the bee to liquefy, and the fly sucked in the resulting fluid. The feeding process took approximately five to ten minutes to complete. Afterward, the empty exoskeleton of the bumblebee might be seen adhering to the plant stem.

We have suggested that the mimicry of the bumblebee by the robberfly may facilitate the mimic's exploitation of its model as food. This means that bumblebees would tend to defend themselves more successfully against those forms of the robberfly that least resemble it. On the other hand, those robberflies that closely imitate the bumblebees would tend not to be noticed until it was too late for a bee to defend itself or to escape. This would favor the survival of robberflies that look like bumblebees, and thus would bring about the evolution of mimicry. Experiments to test this idea have not yet been conducted. A possible procedure would be to confine the insects in a room-size screen cage. Thus, one could observe large numbers of a robberfly species that closely mimics the bumblebees actually attacking them. Then, robberflies of a species that does *not* resemble bumblebees could be introduced into a similar cage with bumblebees. The relative success of both robberfly species in attacking bumblebees could then be compared. Batesian mimicry, which was described in the toad experiments, and the suggested aggressive mimicry, both favor the enhancement of the resemblance between the mimic and the model. There is no reason why the two selective forces could not work together and be cumulative in their effect.

Further experiments on the degree of protection afforded the mimic by a very noxious model in comparison to one less so, the duration of memory of the predators, and their discriminatory ability are a few of the important points to be studied in the laboratory and in the natural environments of the animals. Complicated and fascinating groups of tropical insects, and even Bates' classical butterflies, still remain to be investigated.

Toad eats dragonfly, demonstrating discrimination. Also, the toad proves it is hungry, thus eliminating satiety as a reason for rejection of robberfly.

Part II

Qart Hadasht

Despite scant artifacts, tombs and tophets hint at Punic life

By Kenan Erim   Illustrations by Hans Guggenheim

The Romans who conquered Carthage in 146 B.C. (Natural History, March, 1962) performed their task of destruction all too well. Although they may have failed to raze everything, succeeding generations—both barbarian and Arab—eradicated most remnants of Punic Carthage. It was not until the nineteenth century, with the reopening of North Africa to Western travelers, that the first excavations of the site were undertaken. Even then, much destruction and looting occurred at the hands of amateur archeologists and antiquity-peddlers.

In view of the French presence in Tunisia, it is logical that French scholars and archeologists have contributed most extensively to Punic studies. Charles Ernest Beulé was the leader of the first systematic explorations and excavations of the site in 1859. He concentrated particularly on the hill of Byrsa. regarded—because of its position—as the core of the Punic settlement. The latter part of the century witnessed increased activity on the site by the French Direction des Antiquités in Tunisia: R. P. Delattre and Paul Gauckler examined several cemeteries of Punic character, and the remains of Carthage's harbor installations.

In 1922, the discovery of a large number of votive steles near Salammbô delimited the "sacred area" of Carthage, the so-called tophet. In the 1920's, an American expedition from the University of Michigan also participated in the exploration of the tophet. In recent years, this area has continued to attract the attention of such archeologists as Gilbert Charles-Picard and Pierre Cintas, and has proved to be much larger than had been anticipated. The harbors of Carthage—described by the ancient historian Appian—were certainly Carthage's most prized assets. They have been the object of continuous study since the start of the present century.

Artifacts recovered from various excavations and explorations are today mostly in the Bardo and Lavigerie Museums in Tunis. But Punic monumental remains are nearly nonexistent. The few available consist mostly of tombs, tomb furniture, or foundations of an unspectacular character, generally the foundations of fortifications.

Despite the sparsity of such remains, it is possible to reconstruct hypothetically and very approximately the areas occupied by Punic Carthage. The earliest archeological evidence uncovered, near Salammbô. does not particularly conflict with the legendary date for the foundation of the city. This evidence consists of several Cyprio-Phoenician vessels that can be dated to the eighth century B.C. However, it is normal to assume—and scholars do so—that there must have been a Phoenician emporium on or near the site of the future "New City" (Qart Hadasht, or Carthage) prior to the arrival of Tyrian emigrants, the city's legendary founders. The tophet is situated in the core of this early settlement, at Salammbô, on the height known as the hill "Saint-Louis," which is almost certainly the fortress of Byrsa. The city of Carthage itself must have extended gradually from the shore toward the interior and along the coast.

What are probably remains of the city's great fortifications have been found in the western angle of the site. The defenses appear to have been formidable. Historical sources speak of walls to a total length of fifty-six miles, and some of these were as much as twenty feet thick. Square towers were built at intervals along the walls. The commercial center of the city is believed to have stretched between the height of Byrsa and the harbors. Construction must have been multistoried within the city, but elegant houses and palaces sprawled out to the north, into the rural area that is known as Megara.

Punic civilization having been essentially mercantile, it is normal to conclude that the New City's political aims were conditioned by trade and industry. The very structure of the Carthaginian Empire suggests that the widespread Punic emporiums were not established exclusively as ports of call for Carthaginian merchants in search of raw materials. Rather, they were selected as starting or terminal points for a traffic in large quantities of goods that the Carthaginians either processed or traded. The latter commodities included gold and ivory from Africa (as well as slaves), grain, wine, and olive oil from Sicily, and silver and copper from Spain and Sardinia. Among the processed goods exported by the Carthaginians were, presumably, pottery and textiles (including the famous purple cloth of Tyre), embroideries, unguents, jewelry, and furniture. The fragile character of most of these items makes their archeological preservation improbable.

Nonetheless, it is odd that material evidence for Carthaginian presence or commerce is rarely found in the various points that we know from historical evidence were reached by the Punic expansion. Furthermore, it is likely that in many instances the Carthaginian traders acted merely as middlemen in the transfer of commodities manufactured elsewhere. Still, the archeologist would be a happier man in the unlikely event that some "type fossil" of Carthaginian trade—say, a distinctive kind of pottery—were to be identified in the New City and were then found at the many sites the Punic merchants are known to have visited.

The very nature of its activities and its historical background make Punic civilization and culture extremely difficult to conjure up. The international contacts of the Carthaginians, as well as those of their Phoenician brethren,

Statue of Tanit at temple close to Carthage dates from third century B.C. Representation of the god as having a lion's head betrays Egyptian influence.

GREEK INFLUENCE shows in Punic masks and razor. Masks may be, from left, image of Tanit, a satyr, and mask worn by a dancer or an actor. Egyptian-style bronze razor, found at Utica, bears a scene of Hercules fighting the Minotaur.

colored and influenced their evolution—their arts, architecture, and crafts. The historian Appian, of the second century A.D., gives us a description of Carthage, but his account lacks precision. The capital was undoubtedly adorned with monuments worthy of the New City's position and the wealth of her citizens, but as noted earlier, the remains unearthed by archeologists are so scanty that even foundations available for careful study and eventual, conjectural reconstruction are rare. The few sections of fortification wall extant on the site—near the sea, at Byrsa, and in the vicinity of the lagoons where the ancient harbor installations are believed to have been located—reveal the use of large, square or rectangular blocks of stone, either superimposed without any mortar, or sometimes with a binding made of small stones mixed with a sandy cement. Other haphazard remains show the use of stucco, often decorated or carved, over stone walls, and fluted columns definitely of Greek or Egyptian inspiration. The columns showing Egyptian influence were surmounted by capitals that represented a lotus or a head of Hathor, the Egyptian goddess of love and merriment. Because the cow was sacred to Hathor, the goddess was often depicted with a cow's head or ears. The Greeks identified Hathor with Aphrodite.

It can be assumed that brick construction, concrete, and rammed earth (pisé) work were known to the Carthaginians. Concrete, at least, would have been almost essential for certain types of harbor and jetty installations.

THE most abundant testimonies of Punic civilization stem from tombs and necropolises. Not only do these burial places sometimes give a few hints of architectural conventions in general, but also, above all, they illustrate remarkably well the beliefs of the Carthaginians, especially in matters of religion. Excavations reveal that funerary practices varied from period to period and from one class of society to another. Both inhumation and cremation are encountered.

The earliest tombs, dating from the seventh century B.C., consist of chambers cut out of the bedrock or built up with masonry. From the fourth century B.C. on, vertical shafts were dug, in the manner of wells, frequently to a great depth, with chambers opening on one side of the shaft, one above another. The shaft was filled up gradually as each side chamber was used, and generally each chamber contains more than one burial. In later periods, both the depth to which the shaft was sunk and the dimensions of the chambers themselves appear to diminish. In a few instances, some remnants of superstructures indicate the presence of mausoleums that were aboveground at the head of the shaft.

The presence in these tombs of such grave furniture as pottery, jewelry, and toilet articles is interpreted as indicating a belief in an afterlife. It is difficult to conclude from available evidence whether a cult of the dead or a hope for a better life after death existed, although some foreign influences must have made themselves felt

hrough the Greek mysteries of Demeter and Kore, undoubtedly known to he Carthaginians from Sicily, and the Egyptian cults of Osiris and Isis.

MUCH information concerning Punic religion is obtained from excavated remains of another sort: he votive offerings and the inscriptions. Thanks to these testimonies, many names of divinities and aspects of their cults are preserved, and these ndicate close and continued relationship between Carthage and Phoenicia. The two divinities almost constantly named or invoked are Tanit and Baal Hammon. Tanit, possibly an African variation of the Phoenician Elat or Asherat (later assimilated to the Roman Juno and Caelestis), was a unar goddess of fertility. Baal Hammon (literally, the "Master of the Steles") was—like Tanit—a sky god, perhaps a mixture of the chief Phoenician divinity, El, with an indigenous god of North Africa. Other deities, like Melqart, Eshmoun, and Astarte, are mentioned in inscriptions: an important temple atop the citadel of Byrsa was dedicated to Eshmoun.

Although these divinities appear generally to have been anthropomorphic, older and more primitive traditions of representing them by certain signs—encountered on ex-voto inscriptions—prevailed for a long time. The so-called sign of Tanit, for instance, consists of a triangle with a horizontal line on the top angle lengthened on both sides by two "elbows," and a circle or discus. In other instances, a simple raised stone—known as a baetyl —seems to have served as a primitive symbol or image of the divinity.

The most formidable force of the Punic pantheon was without a doubt Baal Hammon. To win his favor, to expiate a sin, or to placate his anger, the worshiper had to offer a sacrifice, and the sacrifice was indeed the essential part of the religious act. Human immolation appears to have been a very common sort of sacrificial act: more particularly, the sacrifice of children, especially the first-born. Although substitutions were possible (either a slave, a lamb, or a portion of meat), Baal did not seem to be satisfied easily with anything but young, human flesh. This shocking ritual, identified in the Bible as a Canaanite practice (see Genesis, chapter 22:1-18, in which Abraham prepares to sacrifice his first-born, Isaac, to Jehovah), attracted much attention and anti-Punic propaganda in Roman times.

There has been considerable speculation as to the actual existence of child sacrifice in Carthage, a concept that is alien to modern man. There can be no doubt, today, that this ritual was a reality: in the tophet, the sacred area reserved for the burial of sacrificial victims, thousands of urns filled with calcinated bones have been unearthed, and epigraphical evidence clarifies all too well the origins and purposes of these ceremonial burials.

The excavations of Salammbô revealed that the earliest of these urns were placed directly on the bedrock and then covered with a heap of gravel; once the tophet was filled, the terrain was strewn with sand to prepare new ground, and new urns were buried with the ashes of the innocent victims, often grouped in twos and threes and fitted with a cippus, or gravestone, on top. In the later burials, an inscribed stele tends to take the place of the cippus. More than five thousand steles have been found; they bear inscriptions that were dedicated to Tanit and to Baal Hammon.

THE temples to the two divinities, especially that of Baal, must have been near this tophet of Salammbô. Unfortunately, no trace of them has been uncovered, as is true of most other sacred or public buildings mentioned by ancient writers. It is more than likely that the temples of Carthage, like their eastern antecedents, included a sacred precinct surrounded

POTTERY ARTIFACTS include jars and perfume burners that were of ritual significance. The jar that is shaped like a bull, perhaps imported from Sicily, was found at Cape Bon. Anthropomorphic vase at right was made in form of woman.

Carthaginian techniques still influence potters in North Africa

While doing research in North Africa for the illustrations for Dr. Erim's article, Mr. Guggenheim was struck by parallels between current pottery techniques in the area and their antecedents in antiquity. His observations are presented on this page. Mr. Guggenheim is indebted to M. Pierre Cintas, on whose book *Céramique Punique* much of this material was based, for his co-operation.

ONE can still observe the living tradition of Carthaginian pottery-making at the village of Nabeul, on Cape Bon, and on the island of Djerba, which is off the Mediterranean coast of Tunisia.

When Phoenician settlers first arrived at Carthage (*ca.* 814 B.C.) they brought with them turned pottery and the technique of making it. Partly because of Carthage's inferior clay, the settler's work was cruder than Phoenician ware, which they imported in quantity. This trade lasted until Sargon's troops occupied Phoenicia in 766 B.C., and even afterward it continued to some extent until Nebuchadnezzar's victory over Tyre in 587 B.C. From then on Carthage relied exclusively on her own pottery manufacture, and Punic pottery was distributed throughout Carthage's trading world. Remains of Punic pottery have been found from Gabès in southern Tunisia, to Gouraya, in Algeria, and from Motya, Sicily, to Ibiza, Spain.

Three main categories of pottery have been found. Large jars known as amphorae were used in wall construction, placed upright in long rows, with layers of dirt between the rows. The pieces have been excavated in an almost perfect state. The second category comprises pottery found in sanctuaries. All these pieces were connected with ritual sacrifice of the first-born. These urns, meant to hold the ashes of the young victims, were made in large quantities and were probably sold at the entrance to sanctuaries. Over the centuries, various levels of urns were gradually built up at the burial sites, and because urn forms changed from time to time, it is possible to establish a complete chronology on the basis of stylistic analysis.

Tomb pottery forms the third category, which can be divided into two classes: objects of ritual importance and utilitarian objects placed in tombs for the use of the dead. The latter provide insights into the lives of the peasants, who used handmade pottery derived from a local, neolithic tradition that preceded the coming of the Phoenicians and that has persisted until the present. The pottery provided for the upper classes, on the other hand, reflects significant waves of influence that became fashionable at various times in Carthage: Phoenician, Egyptian, and Hellenistic.

From excavations at Carthage and observation of today's artisans, we know of Punic pottery-making methods. Deposits of clay for certain kinds of Punic ware have been found and analyzed. The Carthaginians prepared the clay by treading on it, gradually spreading it with their feet into a circle, working from the center outward. This is still done at Nabeul.

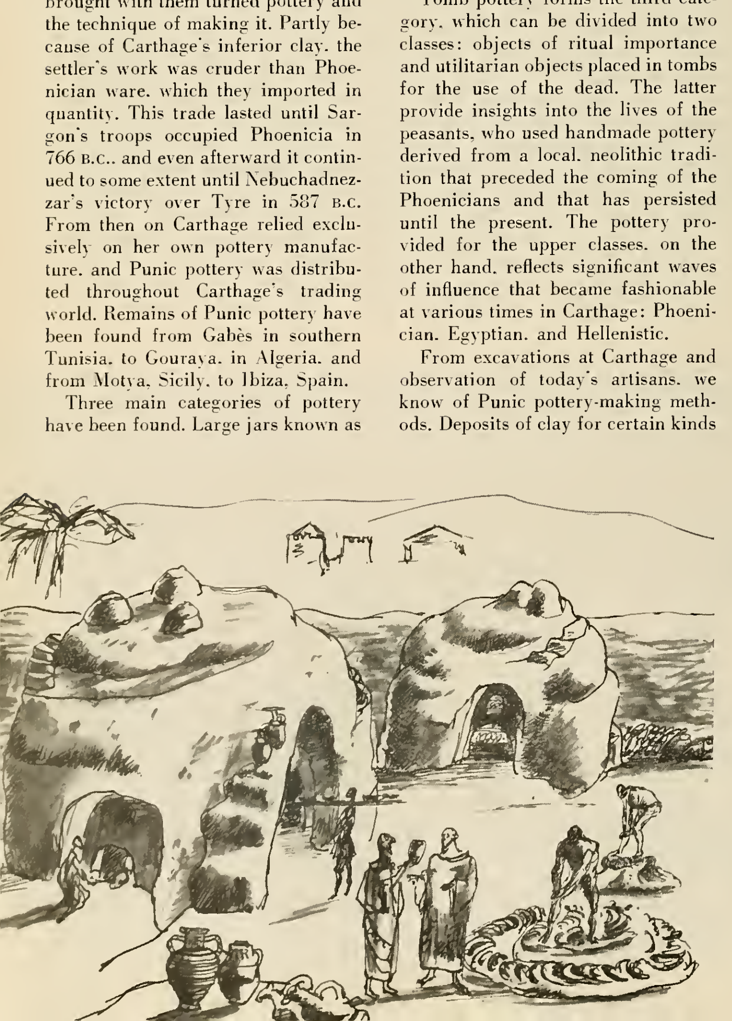
Wheel-turned pottery was also made, and a Carthaginian potter's wheel has been excavated. The wheel was a heavy, circular plate with a carved centerpiece serving as pivot. It must have been worked by two men, one sitting and throwing the clay, the other standing, turning the wheel.

At Deremesh, near Carthage, the six-foot-high remains of an almost complete furnace have been discovered. The furnace was in use when Scipio destroyed the city in 146 B.C. Since Carthaginian kilns were of the same light construction as those used today in Tunisian villages, they had to be destroyed and rebuilt periodically. The destruction of Carthage preserved the furnace and gave it a precise date, confirmed by archeo-magnetic dating.

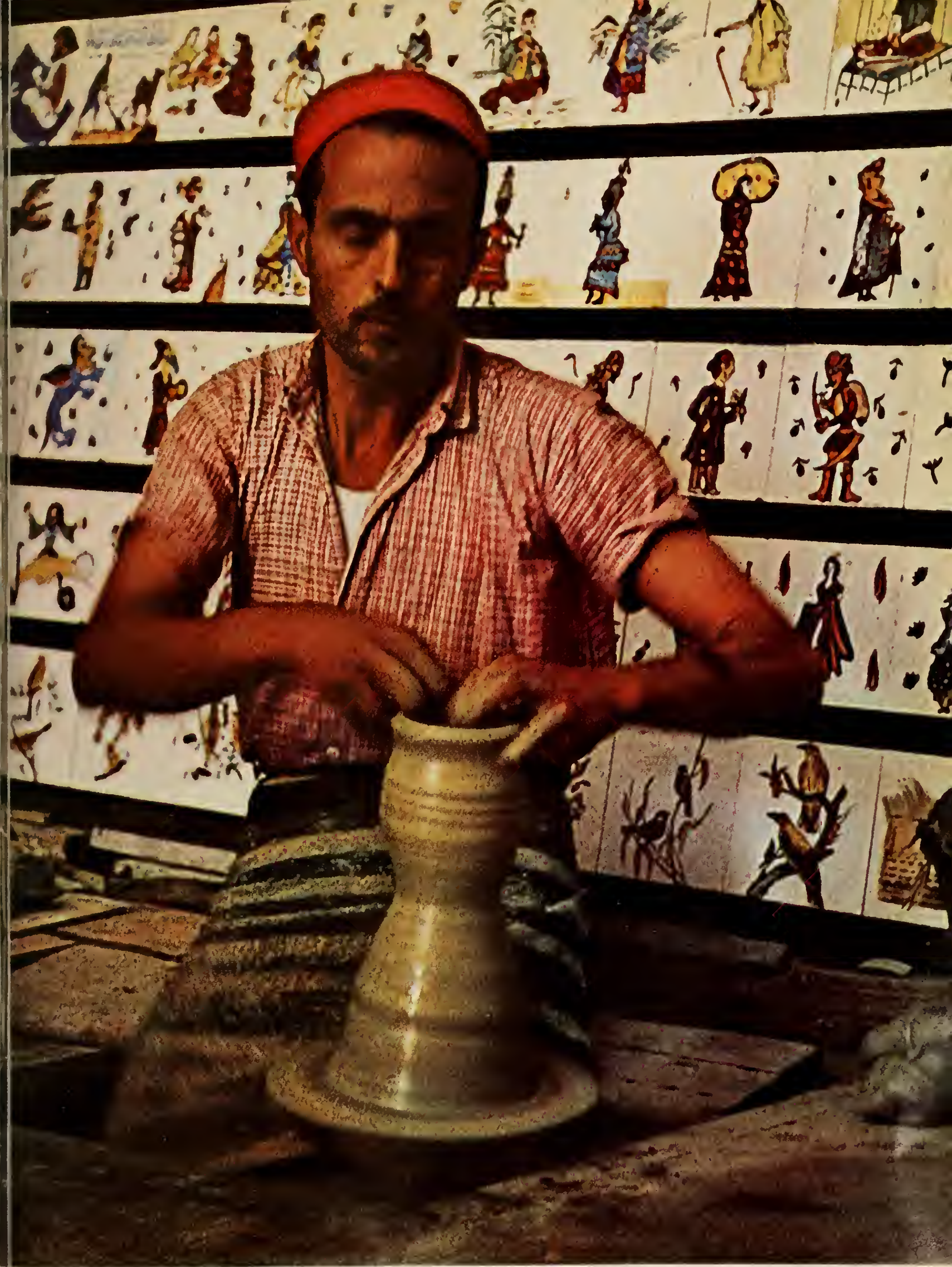
The kiln consisted of an elliptical chamber covered by a high, cylindrical chimney closed at the top by a dome. An open shaft, separated into two floors, divided the inside into two concentric circles. Jars were arranged for firing, according to the heat they needed, in the two chambers formed above the furnace. Heavy pottery was placed around the central shaft. From the heating chamber a small door led into the fire chamber — charred wood and ashes were found in it.

Once the furnace had been loaded with pottery, the flames were kept low for some twenty hours, after which they were fanned to great intensity for five to six hours. A brick wall was then built in front of the furnace door and the fire was allowed to burn out. After two more days the wall was knocked down, and following a cooling-off period of some twelve hours, the pottery was removed. With the kiln, much pottery of varied forms was discovered, neatly stacked and ready to be sold in an adjacent store. Even pots of brown and white paint, used to decorate the jars, were found.

The forms of pottery made today have changed in detail, but basic methods of production are the same.



POTTERS SPREAD CLAY before kilns in a reconstruction of Carthaginian scene.



POTTER FORMS VESSEL in the village of Nabeul, on Cape Bon. Pottery-making in regions of North Africa appears to parallel methods used by Carthaginians. At Nabeul, clay is prepared by treading on it, as it was done in Punic times.

by a wall enclosing a square court in which the temple housing the shrine and the cult-image was situated along with various other edifices, altars, lustral areas, and priestly dwellings.

Some of these temples may well have been located on hills and mountain tops: the temple of Eshmoun was situated on the citadel of Byrsa, if one is to believe Appian. On the other hand, many shrines are known to have been on lower ground or by the shore, and such may have been the case with those of Tanit and Baal. The architectural design of these temples is difficult to visualize. However, from the fourth century B.C. onward, Greek influences—indicated by certain architectural fragments that have been uncovered—must have been strongly felt, and religious structures may well have closely resembled Greek temples.

The same Greek influence holds true in the field of sculpture: little originality is displayed in most Carthaginian representational art, and the Punic debt to their Hellenic (especially western Greek) and Egyptian neighbors is evident. This can be verified by discoveries not only in Carthage but also at other Punic sites of North Africa. The most original creations of the Carthaginians were various amulets and prophylactic masks found in the tombs dating to the seventh and sixth centuries B.C.: these artifacts, some of which were made of terra cotta or colored glass, represent men or women with exaggerated features and appearances—often grimacing and with frightening contortions of the face—seemingly intended to put evil spirits to flight. Their sizes vary, but none is life-size. Consequently, the larger masks may have been hung upon walls—or, possibly, worn by children—while the small ones presumably served as amulets.

Punic pottery offers few unusual shapes and types. The most plentiful vessels are the sacrificial urns. They are ovoid in shape and gray in color, with two rather large handles. These and other types of Punic pottery indicate that the potter's craft here was utilitarian, and not a form of fine art, as in Greece. In jewelry, however, the goldsmiths and silversmiths of Carthage, like their Phoenician com-

Carved stele, near Carthage, marks grave of child sacrificed to Baal, *left*.

Variations appear in signs of Tanit on steles, *above*. Among other motifs are Tanit's hand, a tree, a boat, and less common representations of priest.

DR. ERIM, of New York University, concludes here his articles dealing with Carthage. The illustrator, MR. GUGGENHEIM, has a Charles Kriser Fellowship in anthropology at N.Y.U.

patriots, produced many handsome creations. Some of the tomb finds testify to their skill, while a great many bracelets, necklaces, and pins discovered by archeologists in the western Mediterranean may well be considered of Punic manufacture or inspiration, because of their resemblances to Phoenician as well as Punic types. Punic artisans were especially successful in the *repoussé* and *grenetis* techniques of goldsmithing. In *repoussé* work, a relief design is hammered into the metal from the reverse side. The *grenetis* method consists of forming a pattern or motif on a metal surface by applying tiny beads of metal. The beads were sometimes of silver or gold.

NEITHER the lack of an obvious cultural heritage from Punic civilization in the world of today nor the curse that Roman tradition placed on the name of Carthage should lead one to neglect the real achievements of the Carthaginians. Although the role played by Phoenician as well as Punic culture in the development of Western civilization often appears hazy and uncertain, its importance increases as each new archeological discovery is made in the region. It is a mistake to dismiss these peoples as mere merchants, peddlers, and pirates, or to stress only their maritime achievements. The Carthaginians' practical sense, and their knowledge alike of the boundless sea and of the souls of men, led them to reach a maturity all their own in political, social, and economic institutions. It is a pity that so few of these Punic achievements are easily grasped. Although Carthage died without apparent spiritual posterity, the least today's student can do is to attempt to dispel the magic cloud of Punic myth, this antique symbol of wealth, materialism, and tragedy. The true picture, however unspectacular it may be, deserves consideration, since the thankless task of the Carthaginians was to bring a portion of civilization with them wherever they went.

TOPHET OF SALAMMBÔ was the scene of child sacrifices. Temple of Baal was at right, gate to the burial caves at rear.

ORDOVICIAN PANGAEA, surrounded by Panthalassa, broke up to form today's continents, according to Grabau's drift theory. Note Boston at southern icecap.

The "Drifting" Continents

Theories on floating lands vary widely

By J. Wyatt Durham

Students of earth history find certain facts that are not easily explained if they assume that the continents and ocean basins have always had the same relative positions as at present. To explain these facts, some scientists (including geologists, biologists, and physicists) have proposed that our present continents were once parts of one or two large "super-continents" that have since fragmented and "floated" or "drifted" over the surface of the globe into their present positions. This is the theory of "continental drift," or "floating continents." Opposed to this theory is one of the "permanency of the continents and ocean basins." Four groups of troublesome facts have led to the proposals of continental drift: these facts are climatological, geological, biological, and physical in nature. Let us look at these facts in that order.

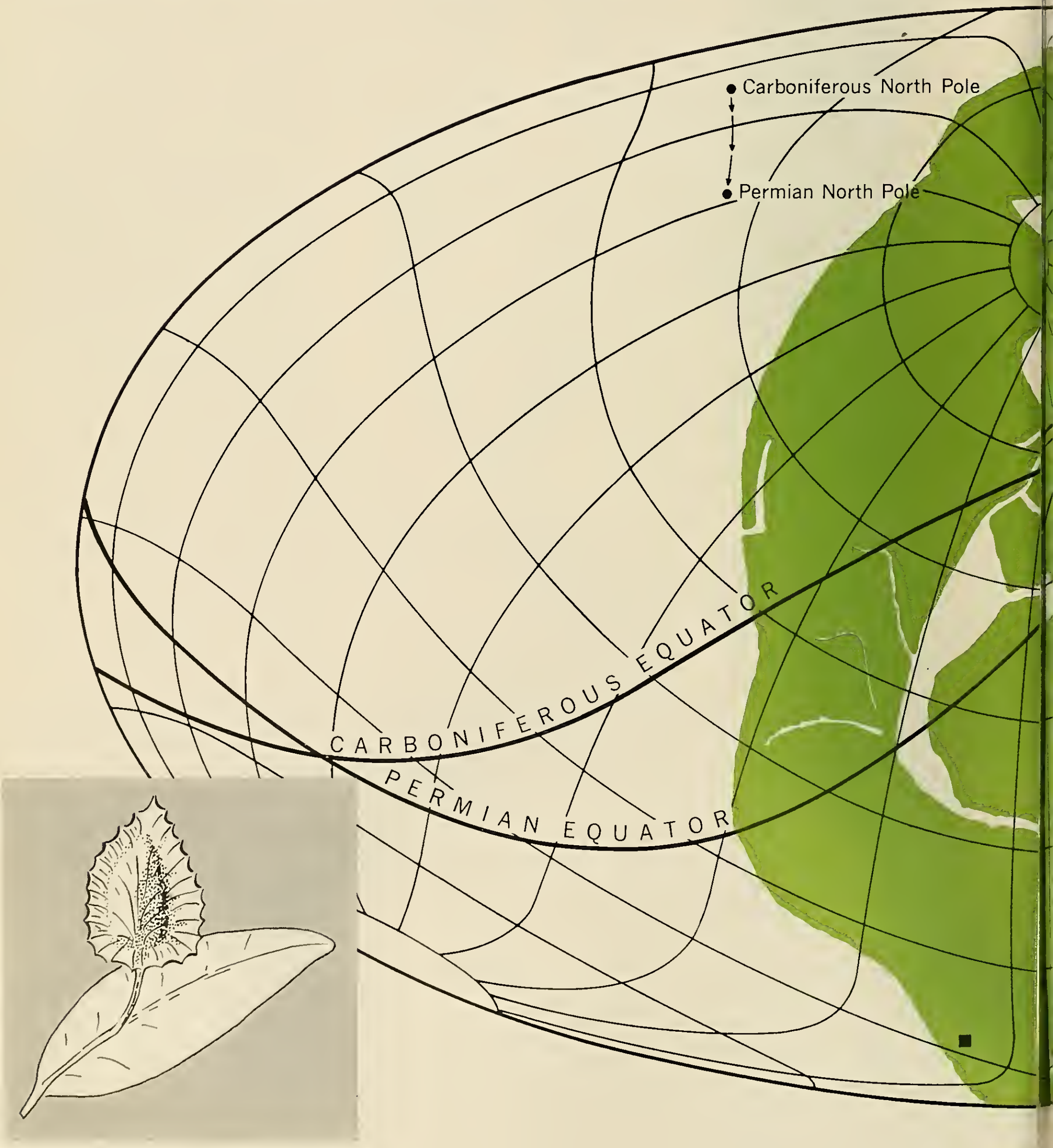
Some of the climatological facts are striking. Characteristic rock deposits (glacial drift) and giant scratches on a smoothed rock surface (glacial striae) give incontrovertible evidence that during the Permian period — perhaps 225 million years ago — there was widespread glaciation in the continents of the Southern Hemisphere and in peninsular India. Today, these are areas that are within the tropical or temperate zones. Further, the glacial striae found on the surface of the ancient bedrock in these areas show that the ice flowed outward from the centers of cold, glaciated areas — and not *into* the area from some colder place. Similarly, evidence now available indicates that widespread glaciation occurred in most of these same southern lands during the Devonian period, perhaps 60 million years earlier, and nearly 300 million years before the great Ice Age of the Pleistocene. Another anomaly is the existence of tropical types of organisms in areas where temperate and frigid climates now prevail: for instance, coral reefs, dating to the Cretaceous, in the Alps and Argentina, and a reef of Triassic date in Alaska. Likewise, deposits of coal, implying a luxuriant vegetation unlike that now present in these areas, are found not only in the temperate zones but also in high latitudes such as northern Alaska and Spitsbergen in the North, and Antarctica in the South. To be explained adequately, all these occurrences require climates other than those now existing in the same areas.

Passing from climatological to geological considerations, the late Paleozoic and early Mesozoic sedimentary rock sequences of Brazil and Argentina are strikingly alike in composition, character, and grain size to those of South Africa. The parallel indicates a similar depositional environment and, seemingly, a common source of materials. Similar rocks occur in India and Australia. The name "Gondwana System" has been applied to these largely non-marine rocks. Because of their wide distribution and the significance attributed to them by geologists, the International Geological Congress has a Permanent Commission for the Study of the Gondwana System as an official part of the organization. Areas along the coast in western Europe and Britain where old mountain ranges formerly existed — known as the Caledonian and Hercynian orogenic belts — closely match the coastal ends of ancient mountain chains in northeastern North America. These similarities between continents on opposite shores of the Atlantic

would be easier to explain if the continents had once been close together.

NEXT, biological data that have been interpreted as favoring continental drift are numerous, but only a few instances can be cited here. One of the outstanding facts in this category is the common occurrence of the peculiar "*Glossopteris* flora" in the Permian of South America, Africa, India, Australia, and Antarctica. In contrast, there are only two *Glossopteris* records in the northern continents. *Glossopteris* was a plant with "tongue-shaped" leaves that has recently (1956) been shown by Edna P. Plumstead of South Africa to possess reproductive structures arising from the leaves and unlike those of any other known plant. In contrast to the highly diverse, contemporary "Euramerican flora" of the northern continents, the *Glossopteris* flora is composed of only a few kinds of plants. This particular fossil flora is found primarily in the various places where late Paleozoic Permian glaciation occurred.

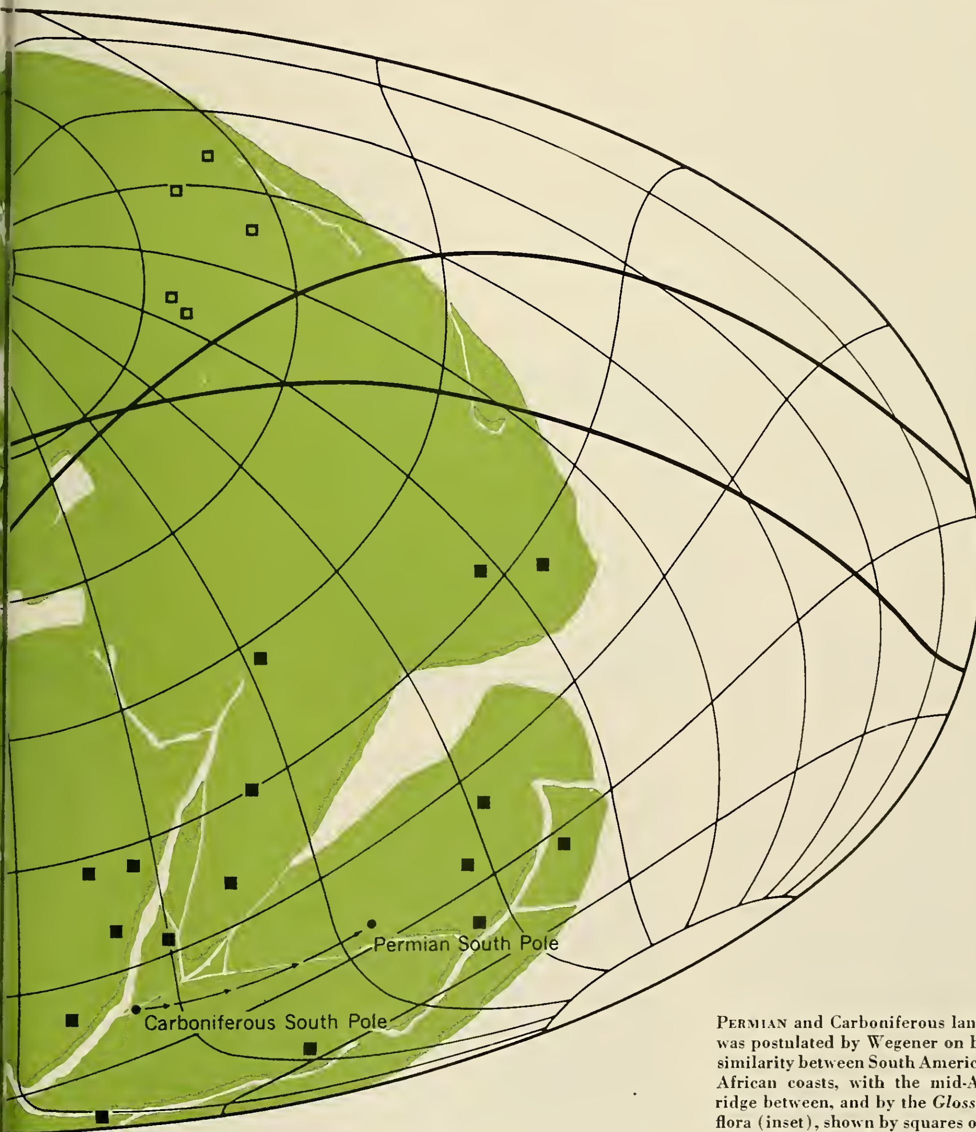
Many of the unusual characteristics of the *Glossopteris* flora have been ascribed to the severe climates associated with glaciation when great areas of the continents south of the Equator were completely covered by glaciers. According to Dunbar's *Historical Geology*, "South Africa has the most spec-



acular evidence of glaciation. . . . The ce cap covered practically all of southrn Africa up to at least latitude 22° ., and also spread to Madagascar which was then part of the continent). There were three or four centers of movement, but the greatest eems to have been in the Transvaal, which then was a plateau from which he ice moved southwestward for a listance of at least 700 miles." In contrast to the late Paleozoic diversification and restricted regional distribution of terrestrial floras, those of the middle Paleozoic were of uniform character and widely distributed.

During the Devonian, a marine fauna, characterized by the brachiopods *Leptocoelia flabellites* and *Spirifer antarcticus*, was present in southern South America, South Africa, the Falkland Islands, and Tasmania. This noteworthy fauna had few elements in common with contemporary faunas of more northern lands. Because of its distinctiveness, the American geologist John M. Clarke once postulated a southern "Flabellites land," named after the first of these brachiopods, to explain the distribution of the fauna.

Let us now consider the final category of troublesome facts. An important finding of the last two decades has been the discovery that the ferromagnetic minerals present in many kinds



PERMIAN and Carboniferous land mass was postulated by Wegener on basis of similarity between South American and African coasts, with the mid-Atlantic ridge between, and by the *Glossopteris* flora (inset), shown by squares on map.

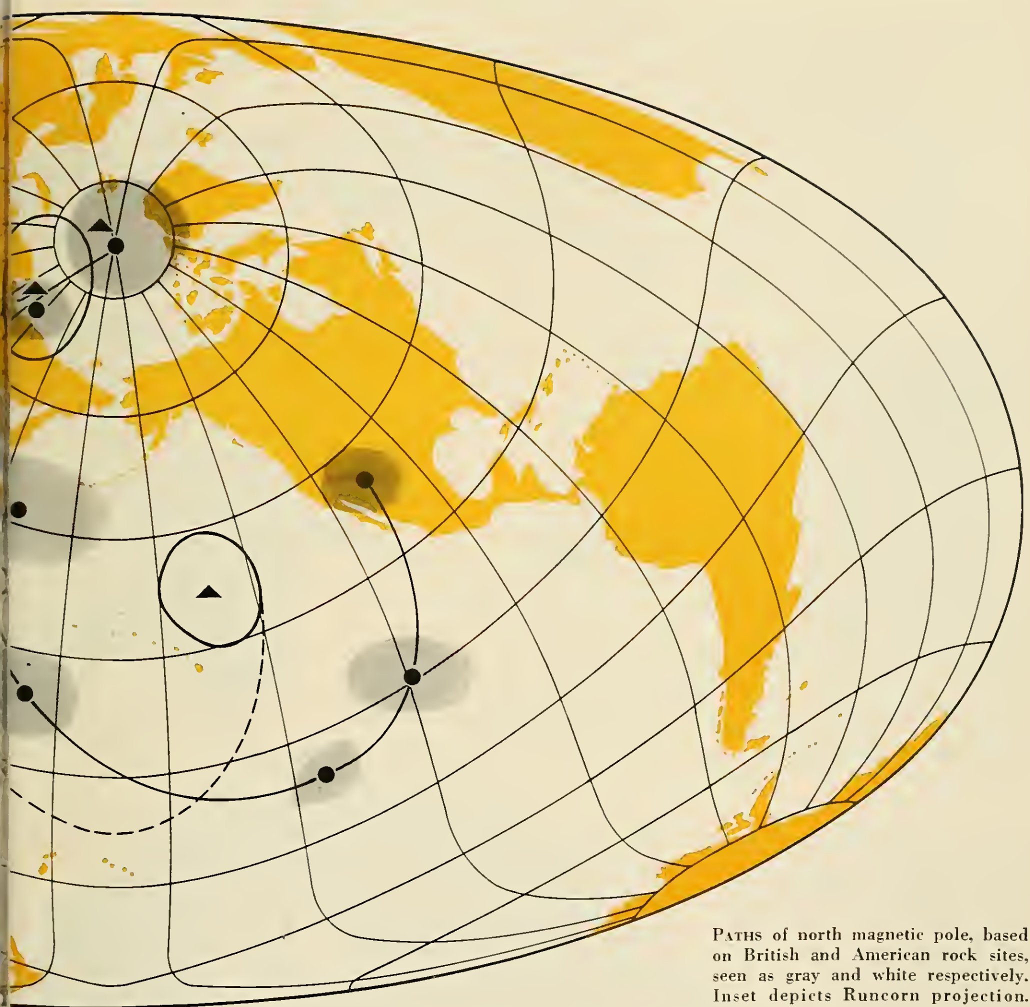
Since 1956, DR. DURHAM has been the Chairman of the Department of Paleontology at the University of California at Berkeley. His main field is invertebrate paleontology.

of rocks are aligned in a pattern reflecting the orientation of the earth's magnetic field at the time the rocks were formed. By careful study of this phenomenon, geophysicists—especially the group working with S. K. Runcorn, now at the University of Durham, England — have been able to reconstruct the orientation of the earth's magnetic field in several different epochs of the geologic past. They have shown that the north magnetic pole has occupied a series of positions in the North Pacific throughout much of geologic time. Only in comparatively recent geologic time has the north magnetic pole approached the present position of the earth's rotational pole. The geophysicists have demonstrated that, during this "magnetic polar wandering," contemporaneous rocks in western Europe and North America indicate somewhat differing positions for the magnetic north pole. Further, they show that, if one postulates a gradual westward drift of North America from Europe through geologic time, these differences can be reconciled. The paleomagnetic evidence would also indicate that peninsular India was at one time south of the Equator and has since moved northward several thousand miles (a conclusion that is in accord with the evidence of Permian glaciation in that land). One of the interesting, and as yet unexplained, facts uncovered by the study of paleomagnetism is that there is an occasional complete reversal of the earth's magnetic field, with the north and south magnetic poles exchanging positions for short (geologically speaking) periods of time.

A number of geologists and other scientists have attempted to explain some or all of the above-noted data by somewhat differing hypotheses that fall in the general category of continental drift. In America, the earliest such proposal seems to have been made by Professor Richard Owen of the University of Nashville. In 1857, he proposed (in his *Key to the Geology of the Globe*) that the continents were formed by the fragmentation of a single, large land mass, pushed apart by a mysterious electrical force whose ultimate source was the sun. Owen's hypothesis was built on fact and supposition, and received little attention.

In more modern times, several different versions of drift have been proposed. In 1940, near the end of a long and outstanding career, the distinguished geologist Amadeus Grabau published his *Rhythm of the Ages*. He considered that the major episodes of earth history resulted from the interplay of alternately expanding and contracting ocean basins—the "pulsation theory"—and the wandering of continents over the surface of the earth.

"All through the early eras of [the earth's geological] history," says Grabau, "the Archaeozoic and the Palaeozoic, the earth's surface was divided into a southern Pangaea and a northern Panthalassa, and though the former shifted about in obedience chiefly to gravitational urge, and in so doing displaced the shores of the ocean, it remained intact until after the end of the Palaeozoic, which, together with the Archaeozoic, comprised by far the greater part of time since the appearance of the lands." Grabau considered that the poles were permanently inclined to the earth's orbit and that thus there were always strongly marked climatic zones that had polar icecaps—the "polar control theory". The moving crust of the earth shifted the continents in and out of different climatic zones, thus account-



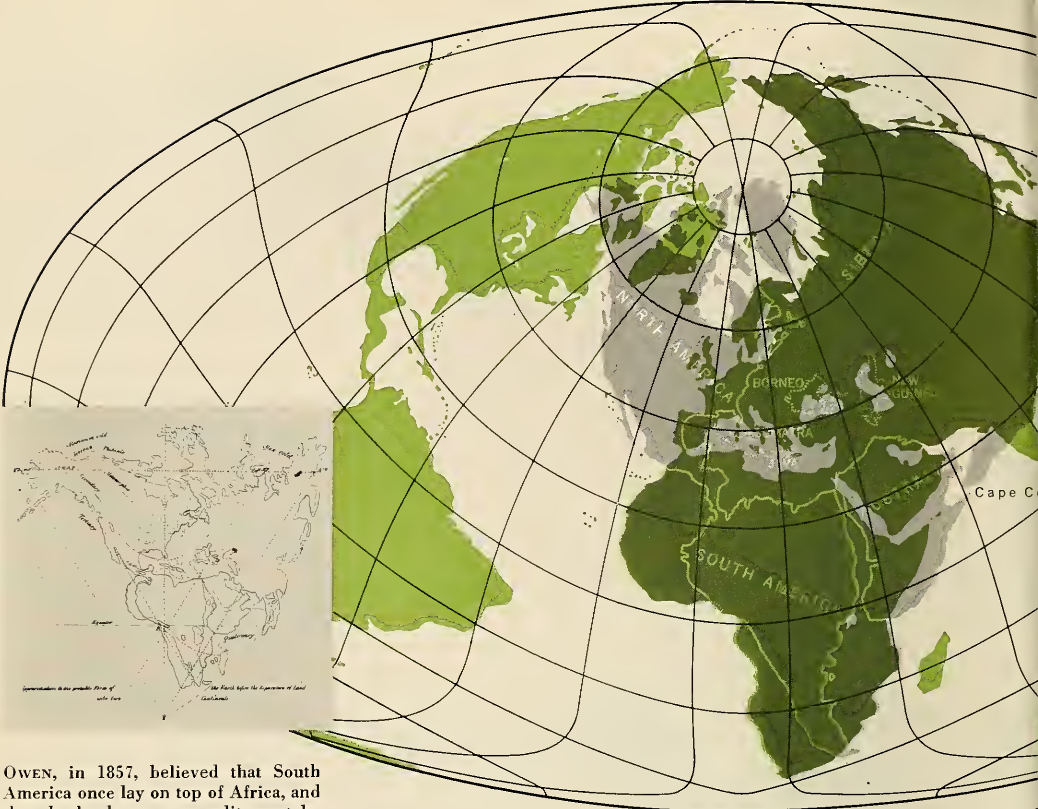
PATHS of north magnetic pole, based on British and American rock sites, seen as gray and white respectively. Inset depicts Runcorn projection.

ng for the evidences of glaciation or ropical climates in areas where these conditions are not now present.

In 1953, the Indian geologist K. P. Rohde published "A New Theory of Sheet Movements and Continental Expansion," in which he proposed that the continents have expanded by fanning out like playing cards from a close-packed deck.

A currently very active proponent of the drift theory is Nationalist Chinese geologist Ting Ying H. Ma, who publishes his own series, *Research on the Past Climate and Continental Drift*, which now totals some fifteen volumes. Ma believes that the continents were originally all part of one large land mass, and that their drifting apart can be attributed to the disturbance of crustal masses caused by the "sudden total displacement of the solid earth shell," and he presents an ingenious assemblage of facts and inferences to support his theory.

A few decades earlier, in 1915, the German meteorologist Alfred Wegener, in attempting to account for the different distribution of climatic zones in the past, presented a version of continental drift that has attracted serious attention. He pointed out the similarity in outline of the eastern South American coastline and the West African coastline, and suggested that the continents had drifted apart from a single, original land mass. Wegener improved and altered his hypothesis as more data came to his attention, but it was left to one of his followers, Alexander L. Du Toit, to modify it significantly. In 1937, Du Toit suggested that there had been two primordial continents: a northern Laurasia (Europe, Asia, and North America) and a southern Gondwanaland (the southern continents plus peninsular India), separated by a seaway (Tethys) and surrounded by the primordial ocean. He also made allowances for the mid-Atlantic ridge and the continental shelf by leaving an appropriate space between the present shore lines of Africa and South America. Both Wegener



Owen, in 1857, believed that South America once lay on top of Africa, and that the land mass was split apart by electrical forces. His own map is inset.

and Du Toit considered that the continents did not begin to separate and move toward their present positions until late in the Mesozoic era, perhaps 100 million years ago, with the major movement occurring within the Tertiary period, during the last 70 million years of earth history.

Wegener and Du Toit marshaled much impressive evidence, both geological and biological, in support of their theories. With the passage of time, however, the latter commented in 1944: "Geological evidence almost entirely must decide the probability of this hypothesis [continental drift] for those arguments based on zoodistribution are incompetent to do so." Nevertheless, Du Toit, like Wegener before him, used paleontological evidence both to date events geologically and thus to establish the time when the continents separated from one another, and to support their theories of the former proximity of land masses.

Continental drift of the type proposed by Wegener and Du Toit has been seriously considered by the geological public and has waxed and waned in popularity. North Americans have generally been the most reluctant to accept it, while geologists working in South Africa and India have often been its strong proponents. Since World War II, the findings in the field of paleomagnetism — especially the differing orientations of the magnetic field in times past—have given the hypothesis new life. Today, it is again receiving serious consideration.

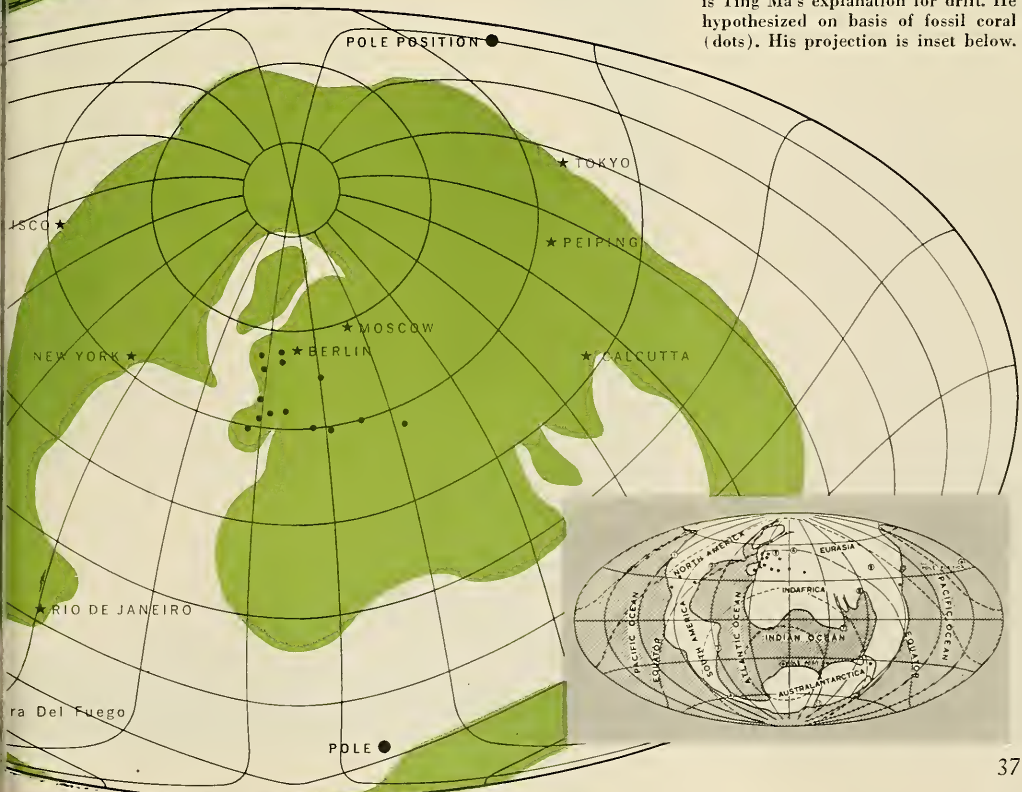
Recently, Bruce C. Heezen of Columbia University has suggested that the mid-oceanic ridges, such as the mid-Atlantic ridge, with their commonly attendant fracture zones, which apparently are due to tension, indicate that the earth has been expanding instead of contracting and that, in consequence, the continents are moving farther and farther apart. While this view is not continental drift in the usual sense, it more or less envisions the continents moving with respect to

one another. and thus should be classed in the same category. This hypothesis is so new and radical that it has not yet been adequately evaluated.

Evidence against continental drift is likewise imposing, and is of several kinds. Both the Wegener-Du Toit version and that indicated by the findings of paleomagnetism require considerable movement of North America away from Europe in Tertiary time. Fortunately, geologists are able to apply the principle of uniformitarianism — the principle that the laws of nature operate today as they did in the geologic past — with considerable confidence in the Tertiary. Faunas and floras of that period are closely related to those now living. We feel sure that their distribution was controlled by the same factors as at present, and that if the continents had changed positions, the distribution would have been affected. For instance, North American upper Eocene faunas from the East Coast and the Gulf of Mexico have only about 2 per cent of the species of Mollusca identical with, or closely related to, those of similar age in western Europe. By way of comparison, about 8 per cent of the living faunas of the same regions are identical species. If the two areas were closer together during the Eocene than at present they should have had a greater number of identical species than at present. Thus, the relationships of early Tertiary marine faunas on the opposite shores of the North Atlantic militates against continental drift.

A similar analysis of the Devonian *Spirifer antarcticus* fauna of the Southern Hemisphere shows that if the faunas of Brazil and South Africa were as close together geographically as most versions of drift require, there should have been greater similarity than is now recognized between them.

Another strong bit of biological evidence against the existence of drift in later geologic time is the composition of the land mammal fauna of South America. Almost all of the Cenozoic terrestrial mammals of South America are obviously derived from ancestors



Sudden displacement of earth's shell is Ting Ma's explanation for drift. He hypothesized on basis of fossil coral (dots). His projection is inset below.

that once lived in North America, rather than in Africa. The geologic evidence indicates that most of the ancestral emigrants from North America arrived in South America very early in the Tertiary, thus demonstrating that Africa and South America were distant from one another at this time.

Proponents of continental drift have usually neglected the effect of suggested closely approximated continental positions in the past on the distribution of marine faunas. Study of modern faunas shows that if areas are much less than 1,000 miles apart and are in the same climatic environment, a large percentage of the elements should be identical or closely related. Thus, instances where only a few species are common to areas that were once supposedly near to one another are immediately suspect because there should have been many more!

When biological data are examined with respect to their bearing on past climates, it is usually found that an alternative other than continental drift is either possible or probable. Widespread tropical climates are indicated by the early Tertiary distribution of organisms of the types now characteristic of the tropics and subtropics. In the early Tertiary, palms were found in Alaska, the northern United States, and Europe. During the Eocene, tropical mollusks occurred along the eastern shores of the Pacific from Peru to Washington. At the same time, similar mollusks were found in the Cape region of South Africa, as well as in England and western Europe, and from Japan to southwestern Australia and New Zealand. In this same interval, plants typical of the tropics were present in northwestern United States, western Europe, and Japan. The application of the principle of uniformitarianism to these data leads to the conclusion that, during the Eocene, the tropical-subtropical zone covered a much greater portion of the surface of the earth than it does now. The Eocene tropics thus included western Europe as far north as Paris and London, Japan, western North America, at least as far as Vancouver, B.C., and essentially all of the currently existing land areas comprising the Southern Hemisphere.

Similar climatic analyses can be made of the biological data for several earlier geologic periods. These show that for much of the time the tropical zone was more widespread than it is at present, and that only occasionally was there a restriction of the tropics, such as during the last Ice Age (which we are still in). If this conclusion as to the usually greater width of the tropical zone in former times is true, then all the biological data indicating past warmer climates in areas outside the modern tropics cannot be used to support the hypothesis of drift, as it no longer requires a different geographic position to explain it.

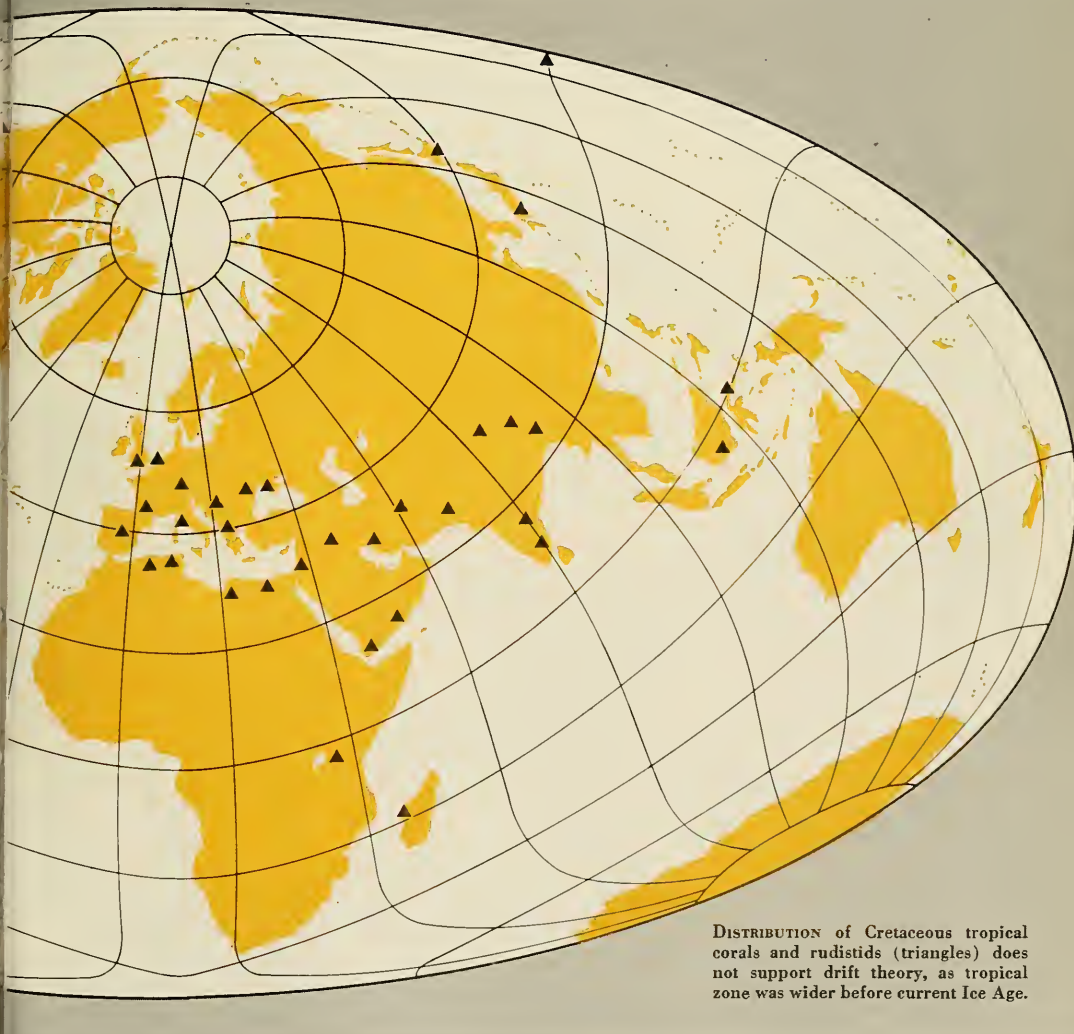
No adequate explanation of the Paleozoic glaciations occurring in the southern continents and peninsular India has yet been proposed, but the associated biological data are easily explained by former island "stepping stones" – islands situated sufficiently close together to have allowed organisms to move from one to another by normal means, thus ultimately reaching the areas where their remains are now found. Further, the similarity of the contemporary marine fauna of

iese areas is not as great as would be xpected had these lands been as close › one another as has been suggested y the proponents of continental drift.

THE geologic similarities on opposite sides of the Atlantic and those etween the elements of the proposed ondwanaland are not compelling reaons for drift. They may be explained y the action of similar forces, by ›rmation of rocks in similar environıents, or by the accumulation of materials derived from similar sources.

The data from the study of paleomagnetism appear to be the most formidable evidence yet adduced in support of continental drift. But, until the principles controlling the earth's magnetic field are better understood, the data are not definitive. No one has yet adequately explained the sudden inversions of the magnetic field, whereby the poles reverse themselves. In addition, the theoretical reasoning indicating that the north magnetic pole has always remained near the earth's rotational pole is not conclusive.

In summary, the existence of continental drift has not been either proved or disproved, although a majority of American geologists feel that the theory of the permanency of the continents and ocean basins is more probable. If drift is proved. one series of problems will be solved, but a new series, requiring further explanations, will be posed, particularly in the wide range of all the biological sciences.



DISTRIBUTION of Cretaceous tropical corals and rudistids (triangles) does not support drift theory, as tropical zone was wider before current Ice Age.

THE ELUSIVE BACHMAN'S

WHERE IS THE BIRD?

Rare warbler of southern swamps is more often heard than seer

By Walter Dawn

Mr. Dawn's wildlife photographs have appeared on these pages in the past. He is also a writer and a naturalist.

One day in July, 1833, Dr. John Bachman, the Lutheran pastor and indefatigable naturalist, threaded his way over rotting hulks of sweet gum and cypress in a swamp a few miles north of Charleston, South Carolina, and moved toward a strange bird whose song was not familiar. Perched on a vine in a thicket was a yellowish warbler with some black around its head. Dr. Bachman aimed his gun, fired, and collected a new bird for science. Later, Audubon described and named "this pretty little species" after his good friend Dr. Bachman.

In hot southern lowlands, in swamps almost impassable, permeated by thick vegetation, red bugs, ticks, dangerous snakes, and other hazards, the elusive Bachman's warbler seemingly veils in secrecy its very local breeding range — a territory still imperfectly known. In over a century and a quarter since its discovery, only a few nests have been found, the first in 1897 in Missouri, and the last some forty years ago, in Alabama. The few records of the bird reveal its winter range as Cuba, although one collected in Florida in January, 1898, a few seen in December, 1932, and one found in 1928 in Georgia, suggest that some winter in swamps of southern states.

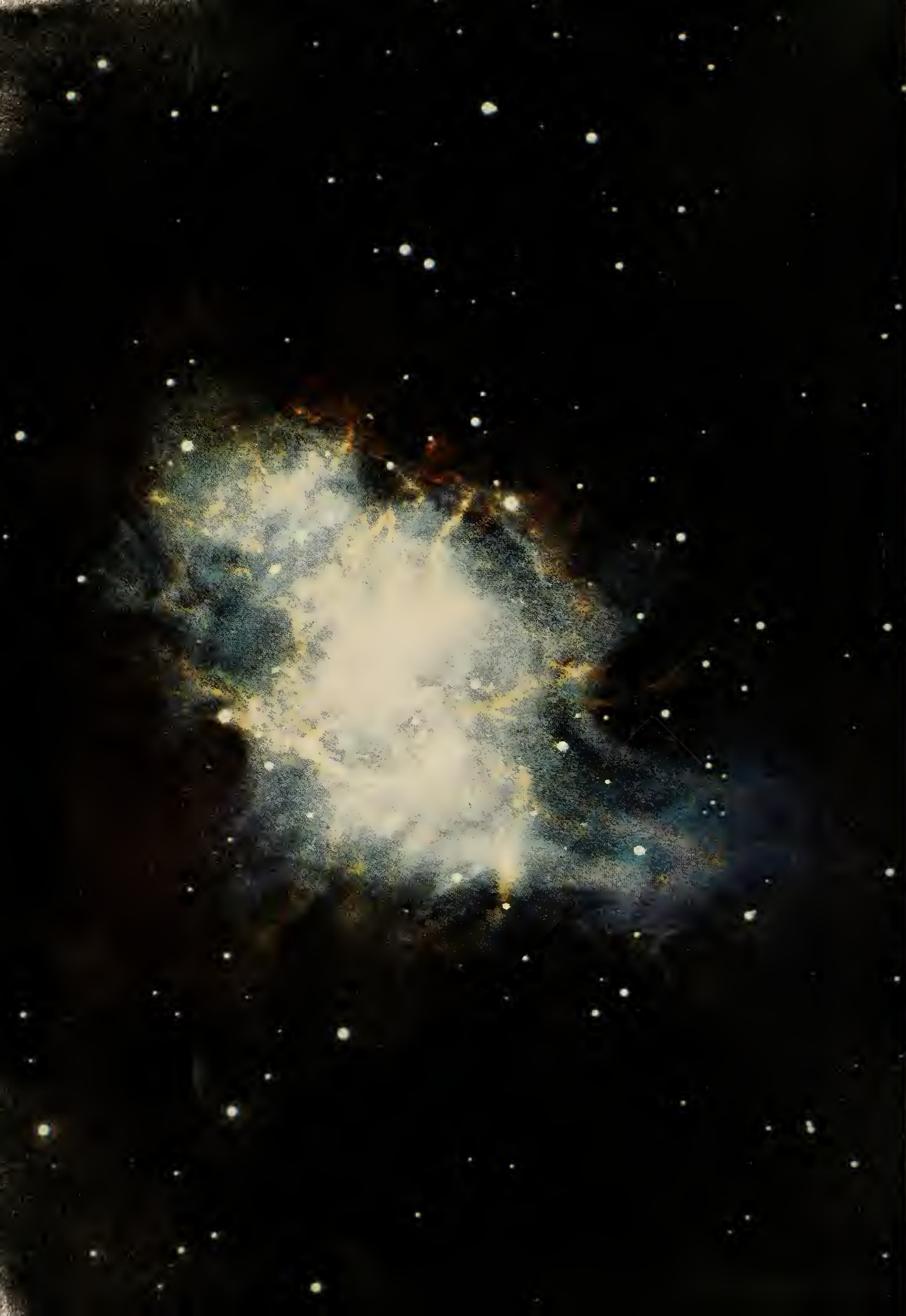
During the waning years of the nineteenth century, specimens of the Bachman's warbler appeared to generate some commercial interest. In 1888, Charles S. Galbraith collected thirty-one males for the millinery trade. He mentions a dozen hunters on the lookout for the bird in 1887. One collector is listed as taking "forty-odd" during the fall migration at Key West, Florida, in 1889, while William Brewste in 1890 collected thirty-six males an ten females along the Suwanee Rive in Florida. Arthur T. Wayne, on hi Suwanee trip in 1892, took fifty.

The early collectors and observer have passed on meager informatio concerning the Bachman's behavio around its nest, so it was a rare op portunity, when, in South Carolina i 1958, I watched a male defend its ter ritory against many different species it aggressively chased warblers, bunt ings, and even a summer tanager fo hundreds of yards. Totally ignorin my presence a few feet away, it onc became locked in combat with a femal prairie warbler near the latter's nest some twelve feet aboveground in live oak. So intent were the birds in th ensuing struggle that I almost caugh them by hand as they tumbled down

How involved does the male Bach man's become in singing and defend ing an actual nest? What part does h assume in the feeding and care of th young? Questions such as these ca only be answered by meticulous obser vation at the nest—when one or mor can be found. In 1905 Wayne observe a male Bachman's feeding an imma ture male. Otto Widmann, collector o the first nest, says that the female "i very tame on the nest." As a result o low nesting, it is undoubtedly subjec to some predation. Thus, any inroad on its small population will have seri ous consequences.

The bird pictured here picked a dry loblolly—longleaf pine association, a most unlikely habitat, adjacent to a bustling highway, near Charleston South Carolina. The intensity of it song was remarkable; with hea thrown back and chest expanded fro one and a half to two times norma size, the notes issued forth in a 180 degree radius, as its body and hea shifted occasionally, creating a ventri loquial quality. Presumably, it faile to attract a mate, although it sang dail for about six weeks on its third con secutive visit in 1960, averaging som 427 songs per hour at its peak.

Head thrown back, warbler sings hi intense song, *left*, and preens his win feathers, *right*, against the geometri design made by longleaf pine needle



SKY REPORTER

Crab Nebula's birth was observed in the Orient 900 years ago

By Simone Daro Gossner

Of the six zodiacal constellations that the sun traverses from the vernal equinox to the first day of autumn—from Pisces through Leo—none has to offer as many beautiful sights as Taurus. The observer unaided by optical instruments is undoubtedly familiar with the striking star groups known as the Pleiades (see map on p. 47) and the Hyades, the latter being the cluster of stars surrounding Aldebaran. To the viewer with a large telescope is reserved the privilege of viewing and photographing one of the most extraordinary features of the entire sky.

The Crab Nebula (see picture on opposite page) is unique in our Milky Way Galaxy, both by its nature and its history. Its first recorded observation as a nebulous object is ascribed to John Bevis, an amateur astronomer of England, who is believed to have seen it in 1731; apparently this discovery did not become known at the time. The nebula was rediscovered by Charles Messier in 1758. In fact, it is the first entry in Messier's famous catalogue of nebulae and clusters, and has been given the designation M1 for that reason. The name "Crab" first appeared in astronomical texts about the mid-nineteenth century.

In 1921, the first remarkable property of the Crab became evident from a comparison, at Mt. Wilson Observatory, of two photographs taken at an interval of nearly twelve years. There was no doubt that, feature for feature, the nebula had expanded in that period. Assuming that they were dealing with a gigantic expanding shell, and turning back the clock, astronomers computed that the Crab had begun its expansion some 900 years earlier. They also determined that at the beginning all its material would have been concentrated at a point near Zeta Tauri (on this month's star map, Zeta Tauri is the star northeast of Aldebaran, and connected with it by a dotted line).

By a remarkable coincidence, some ancient Chinese chronicles, which were being studied in that same year 1921, yielded a number of observations of an unusual astronomical occurrence on July 4, 1054. It seems that on that date a brilliant new star appeared in the constellation Peih (Taurus) near the third magnitude star Teen Kwan (Zeta Tauri). The approximate position of the new star had been carefully recorded. There could be little doubt that the event witnessed in China more than nine centuries ago was indeed the Crab's ancestor blowing itself to pieces.

The Chinese chronicle, unfortunately, gave no clue to the brilliance of the nova at the time of its outburst. Off and on during the decade following 1921, astronomers applied themselves to determining the Crab's distance from earth, which they found to be of the order of 5,000 light-years (this figure was later revised downward to about 3,000 light-years). The nebular remnants are so bright despite their great distance—even if the lesser figure is used—that the astronomers began to wonder if perhaps this was the outburst of a supernova rather than an ordinary nova. The answer to this question required a knowledge of the magnitude of the star at the time of the explosion.

As if on cue, another old chronicle came to light in 1934. This one was written in Japan and also contained observations of the wondrous apparition of 1054. In this case, however, the Japanese astronomers had taken pains to estimate its brightness and had noted that it had become as bright as the planet Jupiter. Here was the last piece of the jigsaw puzzle. By coupling the star's distance with its apparent brightness, it did not take long to verify that the outburst had been that of a true supernova, about a hundred times as bright as an ordinary nova.

The distinction of being the only proved supernova in our own Milky Way of which anything substantial remains would be sufficient to set the Crab apart from all other sky features. Yet the nebula had still another surprise in store for astronomers. When radio astronomy began in earnest a little over a decade ago, and a systematic search was undertaken for celestial objects emitting radiation in the radio frequency range, the Crab came in loud and clear. It has been calculated that in order to maintain its observed brightness both in the optical and the radio range, the nebula is using up energy so fast that it would have consumed all the energy released in the original outburst in about 200 years. Since it is still going strong after 900 years, the only explanation for its longevity is that it is still manufacturing its own energy.

By comparison, the remainder of the northern zodiac is very tame indeed. Even its bright stars have been dethroned from the privileged position they occupied 4,000 years ago. At that time, the spring equinox was in Taurus and coincided almost exactly with the Pleiades. That is to say that when the Pleiades were seen rising in the east just as the first rays of the sun obliterated the morning twilight, the farmer knew that cold days were over and milder weather would soon begin. During the same epoch, Regulus (in Leo) coincided with the summer solstice; it, too, served as a herald of the season. But the continuous displacement of the equinoxes along the ecliptic (Natural History, January, 1962) has left the Pleiades and Regulus stranded somewhere in midseason, and today's farmer must look up the dates in an almanac.

We cannot, however, take our leave without a parting nod at the Heavenly Twins, Castor and Pollux. They are twins only in mythology, for no two brothers could be more dissimilar. Pollux is quite ordinary, but the brighter Castor is, in fact, composed of six stars in such close proximity that the observer's eye sees them as one. If only a telescope is used, three stars can be distinguished—one faint and two bright—and long series of observations reveal that they all travel in orbits around their common center of mass. But a study through the spectrograph discloses that the lines in the respective spectra of the stars are split in the manner that is characteristic of close binary pairs.

THE SKY IN APRIL

From the Almanac:

New Moon	April 4, 2:45 P.M., EST
First Quarter	April 11, 2:51 P.M., EST
Full Moon	April 19, 7:34 P.M., EST
Last Quarter	April 27, 8:00 A.M., EST

For the visual observer:

Mercury, rising a half hour before sunrise on April 1, will be too close to the sun for observation in the early part of the month. It will be in superior conjunction on April 15 and will enter the evening sky on that date. By April 30, the planet will set about one and a half hours after sunset and may possibly be seen at dusk, very low above the west northwest horizon (−0.9 magnitude).

Venus, in the evening sky (−3.3 magnitude), will set one and a quarter hours after the sun on April 1, one and a half hours after on April 15, two hours after on April 30. It will be low in the western sky at the end of twilight.

Mars, in the morning sky (+1.4 magnitude), will rise about an hour before the sun throughout April. The planet will remain poorly placed for viewing. Observers with an unobstructed view of the eastern horizon may be able to see it very low in the sky just before sunrise.

Jupiter, in Aquarius (−1.7 magnitude), will rise at 4:15 A.M., local standard time, on April 1, 3:30 A.M. on April 15, 2:30 A.M. on April 30. It should be clearly visible in the southeastern sky before sunrise, particularly in the last few days of the month.

Saturn, in Capricornus (+0.9 magnitude), will precede Jupiter by one hour during the entire month, rising in the southeast at 3:15 A.M. on April 1, 2:30 A.M. on April 15, and 1:30 A.M. on April 30.

The Lyrid meteor shower may be expected from April 20 to 22 (a few may be visible through April 24). The display was not spectacular in previous years, the maximum rate seldom exceeding fifteen meteors per hour for a single observer; even fewer may be visible this year because of the dimming effect of the just-past full moon.

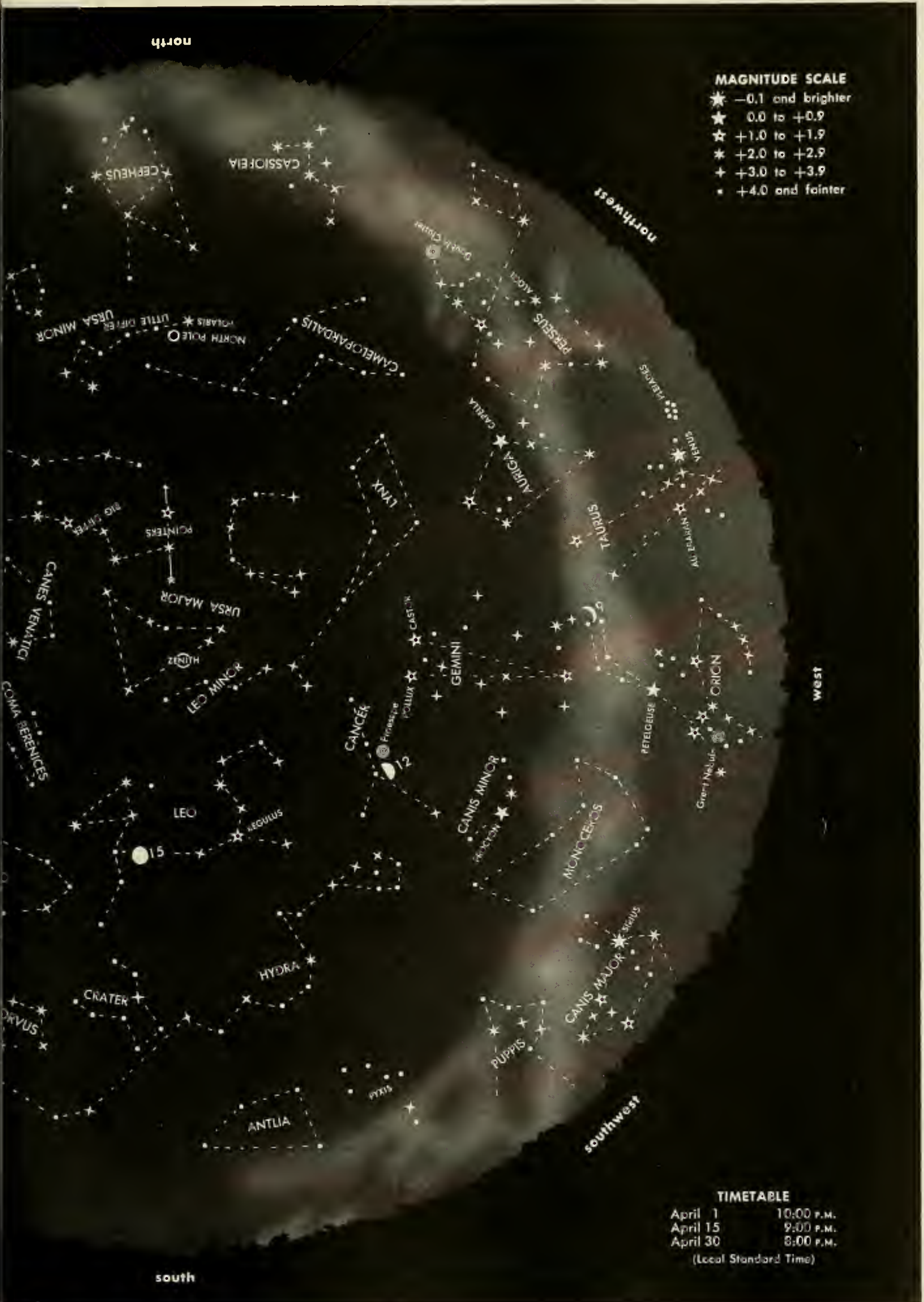
The Great Bear

The great constellation of Ursa Major, which the ancient Greeks called Arctos, is familiar to nearly everyone. Americans know it as the Big Dipper or the Great Bear and Britons speak of Charles' Wain. Actually, the constellation extends far beyond the area delineated by the seven bright stars of the Dipper. It includes all the stars forming a rough semicircle (forked at one end) between the pointers and Lynx, and all those forming the triangle near the zenith of our star map, between the Dipper and Leo Minor.

The appearance of constellations changes slowly over the centuries because the individual motions of their component stars gradually distort the familiar shapes. The Dipper, on the contrary, has remained fairly constant over the ages; its appearance is not caused by a fortuitous grouping of stars at widely different distances from the sun—as is the case for most constellations. It is a part, instead, of a loose physical association in which all stars share a more or less common space motion. The slight differences remaining in their motions will eventually disrupt the association of stars and scatter the individuals.

On the preceding pages, MRS. GOSSNER offers the fourth in her 1962 series — a survey of the celestial sphere.

To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.


north
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
northwest
CEPHEUS
CASSIOPEIA
URSA MINOR
LITTLE DIPPER
POLARIS
NORTH POLE
CAMELOPARDALIS
Double Cluster
ALGOL
PERSEUS
PLEIADES
CAPELLA
AURIGA
VENUS
LYNX
TAURUS
ALDEBARAN
BIG DIPPER
POINTERS
CANES VENATICI
URSA MAJOR
ZENITH
LEO MINOR
CASTOR
GEMINI
POLLUX
ORION
BETELGEUSE
west
COMA BERENICES
CANCER
Praesepe
12
CANIS MINOR
PROCYON
Great Nebula
LEO
REGULUS
15
MONOCEROS
SIRIUS
CANIS MAJOR
HYDRA
CRATER
CORVUS
PUPPIS
PYXIS
ANTLIA
southwest
TIMETABLE
April 1 10:00 P.M.
April 15 9:00 P.M.
April 30 8:00 P.M.
(Local Standard Time)
south

Teeth of the IGUANODON *a newly discovered* FOSSIL ANIMAL, *from the Sandstone of* TILGATE FOREST, *in* SUSSEX.

Portion of the Jaw of the Iguana. four times magnified.

J.s Basire sc.

Some Victorians and the Dinosaurs

Problems and personalities marked first decades of excavating

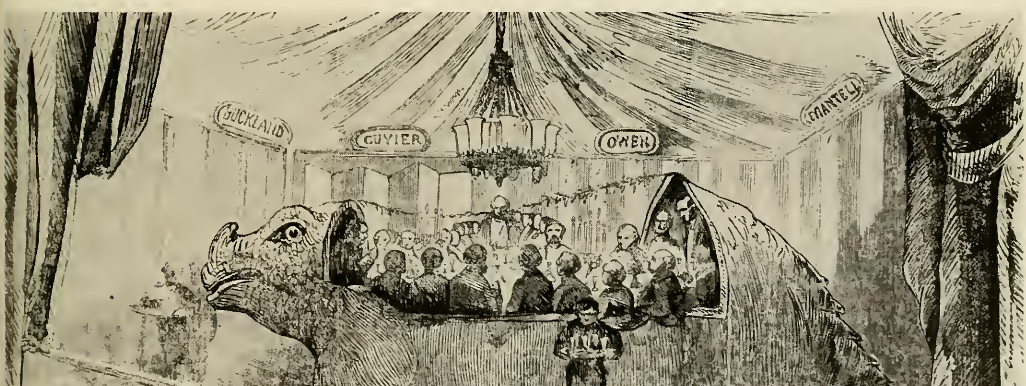
BY EDWIN H. COLBERT

A CENTURY AND A HALF AGO, dinosaurs were quite unknown. Until the early days of the 1800's, even the most knowledgeable men had looked at dinosaur bones with unseeing eyes; they had looked, but they had not understood what they had seen. In early historic times, and even through the centuries of medieval Europe, people were prone to attribute large fossil bones to giants. Indeed, some ancient legends of giants may have been based in part on the discoveries of large fossil bones—usually the bones of extinct elephants, but now and then, perhaps, the bones of other large extinct vertebrates, including dinosaurs.

By the beginning of the nineteenth century, however, rational explanations for natural phenomena were being sought. No longer were intelligent people satisfied with tales that taxed credulity; nature had to be explained in accordance with uniform natural laws. It was the age of reason.

The first dinosaur to be properly described was discovered on a morning in March, 1822, in Sussex, England, by the wife of Dr. Gideon Mantell. A physician in the city of Lewes, Mantell was a man of wide interests. He was particularly interested in fossils, and for some years had spent his spare hours in the countryside of southern England, searching for the petrified remains of extinct animals. His wife often accompanied him.

On this particular day Dr. Mantell drove some miles outside Lewes to at-



FIRST PUBLISHED ILLUSTRATION of the Mantell's *Iguanodon* finds, *left*, reveals simple origins of all dinosaur studies.

INCONGRUOUS DINNER PARTY in 1853, given inside *Iguanodon* reconstructed by Hawkins, is shown in contemporary sketch.

tend to one of his patients, and his wife went along for the ride. While he was in the house of his patient, Mrs. Mantell walked up and down to pass the time. In the course of her walk, she saw some rocks that had been piled by the road. She noticed an object in one rock that looked most unusual—it had the definite form and the shining surface of a fossil. The object was a fossil tooth, which she showed her husband.

It was a tooth quite different from any fossil that Dr. Mantell had seen before, and it aroused his curiosity. In ensuing weeks he returned often to the country near where it had been found, and located not only more teeth like it, but also a number of fossil bones, all unfamiliar to him.

In those early days of paleontology, there was one great authority to whom other students of fossil vertebrates might turn for help: Baron Georges Cuvier of Paris. Cuvier, with good reason, has been called the founder of comparative anatomy and the father of vertebrate paleontology. In the 1820's, he was nearing the end of his wonderfully productive life; he had behind him the vast experience of long years of research.

For all of that, when Mantell sent his fossils to Cuvier, the French scholar first identified the teeth as those of an extinct rhinoceros and the bones as those of an extinct hippopotamus. Because he was certain that the fossils came from rocks far too ancient to have contained the remains of advanced mammals, Mantell next sought the advice of Oxford's Dean Buckland, one of the founders of paleontology in England. Buckland urged Mantell to do nothing at the time; above all, to publish nothing! Buckland was ready to accept Cuvier's identifications, which led him to the conclusion that the fossils were remains that had been found in superficial deposits of comparatively late geological age.

But the obstinate Mantell was not convinced either by Cuvier or by Buckland. He decided to make a detailed study on his own behalf. At first, he made little progress, for he could locate nothing—ancient or recent—that resembled the fossils in his possession. Then another communication from Baron Cuvier started Mantell on the right track. "Do we not have here a new animal," suggested Cuvier, "an herbivorous reptile? And even as among the modern terrestrial mammals it is within the herbivores that one finds the species of the largest size, so among the reptiles of another time, then the only terrestrial animals, were not the greatest of them nourished on vegetables?" If, concluded Cuvier, teeth could be found in a jaw, the problem might be resolved.

Emboldened by this response, Mantell pursued his investigations, but to no avail. Then one day in 1825, when Mantell was comparing his fossils with various specimens in the Museum of the Royal College of Surgeons in London, he met a naturalist named Samuel Stutchbury, who had been studying iguanas—large lizards that inhabit Mexico and Central America. Stutchbury immediately saw that Mantell's fossil teeth resembled those of an iguana, but on a much magnified scale. Here was the clue that Mantell needed; in that same year, he published a description of the fossil teeth under the name of *Iguanodon* [iguana tooth].

In 1833 Mantell moved from Lewes to Brighton, because he felt that in the latter fashionable resort, then fre-

MODERN RECONSTRUCTION of *Iguanodon* shows protuding thumb-spike. The 19th century restorations erroneously placed this spike as a horn on animal's nose.

ONE OF THE FIRST three fossil reptiles to be described, the *Megalosaurus* is depicted in this modern restoration. A jaw with large, bladelike teeth, found near Oxford, England, by Dean Buckland, established it as a carnivorous reptile.

quented by royalty, he might get support for his work on fossils. Just before he moved, he had described a partial reptilian skeleton he had found, and he called it *Hylaeosaurus* [forest lizard]. Two years later a discovery was made near Maidstone, Kent, that at last was to give something of a clue as to the nature of *Iguanodon*. A slab of rock, found in a quarry, contained *Iguanodon* teeth in association with various bones of the skeleton. The discovery so prophetically hoped for by Cuvier a decade earlier had finally come to light. *Iguanodon* now began to take form as an animal.

MEANTIME, Dean Buckland had described another large reptile, based on a lower jaw and various parts of a skeleton that had been found near Oxford. This was clearly a carnivorous, or meat-eating reptile, with large, bladelike teeth, quite in contrast to the rather leaf-shaped teeth of *Iguanodon*. Buckland gave the name of *Megalosaurus* [great lizard] to the fossil.

By the middle of the 1830's, therefore, three large fossil reptiles had been discovered in the south of England. But, beyond that, their respective places in the tree of animal life were unknown. These three reptiles—*Iguanodon, Hylaeosaurus*, and *Megalosaurus*—were in truth dinosaurs, but no one realized it. Several more years were to pass before another Englishman, Richard Owen, would create the concept of dinosaurs.

Owen was the first great comparative anatomist and vertebrate paleontologist of England, a worthy successor of Cuvier. He had a long and distinguished career. In 1842, much of this career was still ahead of him, yet even then, as a comparatively young man, his word on the anatomical characters and the relationships of the vertebrates carried a great deal of weight. It was in that year, in one written sentence, that Owen brought the dinosaurs into being. In a report on British fossil reptiles, Owen wrote: "The combination of such characters, some, as the sacral ones, altogether peculiar among Reptiles, others borrowed, as it were, from groups now distinct from each other, and all manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe or suborder of Saurian Reptiles, for which I would propose the name of *Dinosauria* [terrible lizards]." Little more than ten years after this, dinosaurs were to be widely known among Englishmen in all walks of life.

THE first world's fair was London's Crystal Palace Exposition of 1851, a new kind of fair to celebrate the technology of steam power and the Industrial Revolution that was rapidly changing the Western world. The Crystal Palace—a great building of iron and glass erected in Hyde Park—was so popular during the time of the exposition that, in 1854, it was removed to a spacious site in Sydenham, away from the center of the city. In the landscaped grounds around the relocated Crystal Palace there were constructed life-sized restorations in concrete of *Iguanodon* and of other animals that had inhabited southern England in the geologic past. These models—reconstructed by a Mr. D. W. Hawkins under the eye of Professor Owen—possessed all the scientific exactitude that could be brought to bear at the time.

In those days, it was thought that *Iguanodon* was a sort of rhinoceros-like reptile, with a horn on its nose. It was restored in this shape for the Crystal Palace grounds. We now know that *Iguanodon* was a large, bipedal dinosaur that walked on strong hind legs, and that the supposed horn upon

Field book from Cope's expedition of 1874 is spread open at one of many perceptive sketches in this diary. It shows a landscape in northern New Mexico where he made one of h most important finds—an Eocene formation rich in fossil

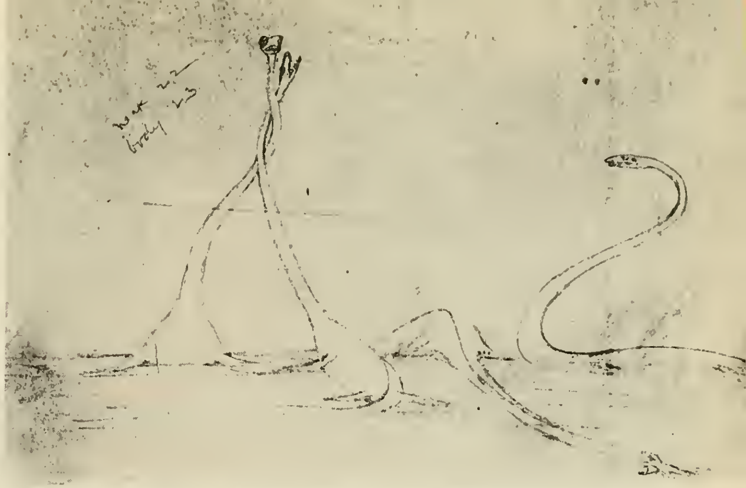
t: nose of the beast was actually a
l ge spike that formed the end of the
t umb. But we need not criticize the
Crystal Palace models because of our
s perior modern knowledge; they
v re laudable and sincere efforts for
t eir time, and they were most effec-
t e. A century later they still stand.

To celebrate the completion of the
_ *Iguanodon* model, a party was
g en at which Professor Owen and
o ier distinguished scientists of the
d y sat down to what must have been
a rather crowded dinner *inside* the
m odel. while the lesser lights ban-
q eted on tables set up around the
r constructed dinosaur. It was a truly
m emorable affair.

According to report, "Cards of invi-
t ion were issued as follows: 'Mr.
 W. Hawkins solicits the honor of
P ofessor ——— 's company at dinner
 the *Iguanodon*, on the 31st Decem-
b r, 1853, at 4 o'clock, p.m.' Mr.
H awkins had one-and-twenty guests
r ound him in the body of the *Iguano-*
d n—before the upper part of the back
a d head was completed. In the chair,
m ost appropriately, sat Professor
O wen, occupying part of the head of
th e gigantic animal; he was supported
b . . . eminently scientific men. . . ."

The first half-century or so of work
o the dinosaurs was the pioneer
p riod—a span of time ending with the
ea rly 1890's. This period was a time
of groping, rather haphazard efforts
of collectors in the field, and of intel-
le tual groping in the laboratory. In
E urope, the first period of early, un-
d rected investigations of the dino-
sa urs gradually merged into a more
m odern period of field work and re-
se arch, based upon a greatly aug-
m ented knowledge, not only of the
di nosaurs, but also of their relatives,
of all extinct life. and of past events
in earth history. In North America,
th e first phase of work on the dino-
sa urs was brought to an exciting close
b y the unrivaled discoveries and re-
se arches of two men, and by the acri-
m onious dispute between them.

The collecting of dinosaurs in North
A merica during the 1870's and 1880's
w as a colorful pursuit. to put it mildly,
a nd studies on the fossils were far re-
m oved from the quiet, objective activi-
ti es that are supposed to encompass
sc ientific research. The reason for the
ex citement is to be found in the con-
fl icting personalities and ambitions of
tw o eminent professors.



Cope's early sketch of *Enaliosaurs* exaggerated the flexibility of neck, but is typical of imagination and artistic skill he brought to bear on his science.

Horned Ceratopsian of Montana, was sketched by Cope on wrapping paper.

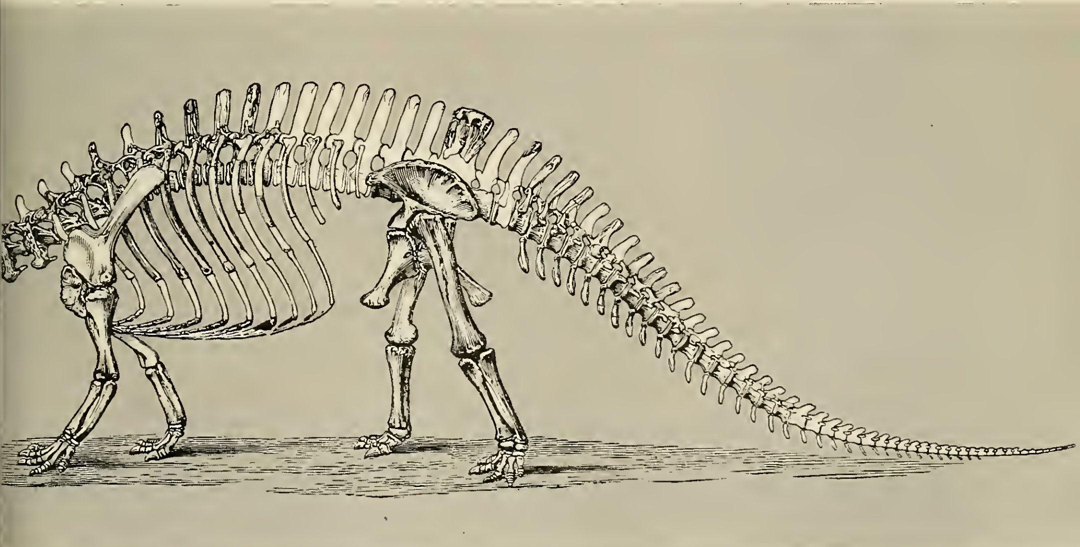
Restorations of two fin-backed lizards, *below*, ably demonstrate Cope's insight.

PORTRAIT OF YALE EXPEDITION of 1870, in the field near Fort Bridger, Wyoming, shows Marsh (standing, fifth from left) and assistants heavily armed—no mere props at tim when there was danger of Indian attacks and horse thieve

OTHNIEL CHARLES MARSH was born in 1831 at Lockport, New York, a region where many cliffs and outcrops of rocks contain fossils of interest to a boy having a larger than usual bump of curiosity and an interest in nature. When Marsh was a lad, his mother died, and subsequently he came under the patronage of his uncle, George Peabody, a man of wealth and influence. Marsh attended Yale, graduating in 1860, after which he studied in Germany for several years. His uncle left him an ample income for life, and Marsh devoted all his time to fossils. He returned to Yale in 1866 as Professor of Paleontology, and immediately launched upon an active career of research on fossil vertebrates. He persuaded his uncle to found Yale's Peabody Museum, which, under Marsh's direction, was to become one of the outstanding natural history museums of North America. He never married, and died in 1899.

Edward Drinker Cope was born in Philadelphia in 1840, the son of a wealthy Quaker philanthropist. Cope was amazingly precocious and, at the age of seven, was making detailed and sophisticated notes concerning the anatomy of an ichthyosaur on display at the Academy of Natural Sciences in Philadelphia. He, too, went to Europe in the sixties, and returned to become a professor at Haverford College. But he did not remain there for long; he had too independent a personality to be confined within the bounds of any institutional organization. Consequently, for much of his life he was an independent worker, financing his own field work and research with the fortune that had been left to him by his father. In the course of time he became an outstanding world authority in at least three fields—the study of recent fishes, the study of recent amphibians and reptiles, and the study of fossil vertebrates. He published prolifically and stands as one of the great men of American science. During his middle age, Cope invested heavily in mines and virtually lost his

ATER COLOR BY ARTHUR LAKES shows Marsh (right) lunching th his two assistants near Como Bluff, Wyoming. Lakes, an English clergyman and geologist, made many such quaint paintings while engaged in digging and sketching fossils.



NE OF THE MAJOR SPECIMENS reconstructed by Marsh, this *rontosaurus excelsus* stands in Yale's Peabody Museum. Nearly all the bones belonged to a single individual that was discovered by one of Marsh's several field assistants.

Dr. Colbert, a leading expert in his field, is Chairman and Curator of Vertebrate Paleontology at The American Museum. The excerpt is from *Dinosaurs*, Copyright © 1961, published by E. P. Dutton & Co., Inc.

fortune. In the last years of his life (he died in 1897) he served as a professor at the University of Pennsylvania, and this appointment helped him through his last, difficult years.

Cope and Marsh were both most able men, brilliant (Cope was a true genius), inordinately ambitious, and wealthy. And both were independent men, accustomed to getting what they wanted. What both wanted was to collect and describe extinct vertebrates. They put their wishes into actions, and in so doing literally discovered a vast new world of dinosaurs.

The two men became acquainted in the early seventies, and at that time they had some pleasant trips together in eastern North America, searching for early dinosaurs and other fossils. Then they turned their attentions to the great open country west of the Mississippi. They began to collect in the Great Plains and in the Rocky Mountain region and, in a very short time, even vast western North America was not big enough to accommodate the two of them. Their rivalry and their jealousy of each other grew by leaps and bounds, and assumed the nature of open warfare. They, and the collectors they hired, spied on each other. They tried to keep their fossil sites secret. Upon at least one occasion their collectors engaged in a free-for-all fight among the lonely ridges of Wyoming. The two professors engaged in vituperative attacks upon each other in the newspapers, and they promulgated all sorts of machinations in scientific societies, in the government surveys on which they served, in universities and museums with which they were connected.

Yet all of this had its good side: their rivalry stimulated them to collect and describe fossils on a grand scale. They sent back tons of bones to New Haven and to Philadelphia, to be cleaned by technicians, sketched by artists, and measured by assistants. In so doing they laid the groundwork for modern methods and techniques of vertebrate paleontology. Marsh and Cope did not rely upon the chance discovery of fossils. They planned well-integrated campaigns of fossil-hunting and collecting. They developed methods still in use for taking large bones out of the ground. They maintained well-staffed laboratories, and published their studies in two blizzards of scientific reports.

Cope and Marsh ranged far and wide in their search for dinosaurs, and each made outstanding discoveries. Cope discovered and described primitive Triassic dinosaurs from New Mexico. He opened a large quarry in the Morrison deposits—of Jurassic age — near Canyon City, Colorado, and there excavated some excellent skeletons. One of Cope's finds—the skeleton of the carnivorous *Allosaurus*—was still in shipping boxes, unopened and unstudied, when The American Museum of Natural History purchased the Cope collection in 1895. Cope also described Cretaceous dinosaurs, especially from Montana's Judith River.

The outstanding discovery by Marsh was the great deposit of skeletons in the Morrison sediments along Como Bluff, in eastern Wyoming—one of the most prolific and famous dinosaur localities in the world. From this site, Marsh and his collectors excavated a treasure-trove of skeletons, some of which are now displayed in Yale's Peabody Museum. Marsh also collected Cretaceous dinosaurs, especially from the region near Denver. It was from here that he made known the existence of horned dinosaurs.

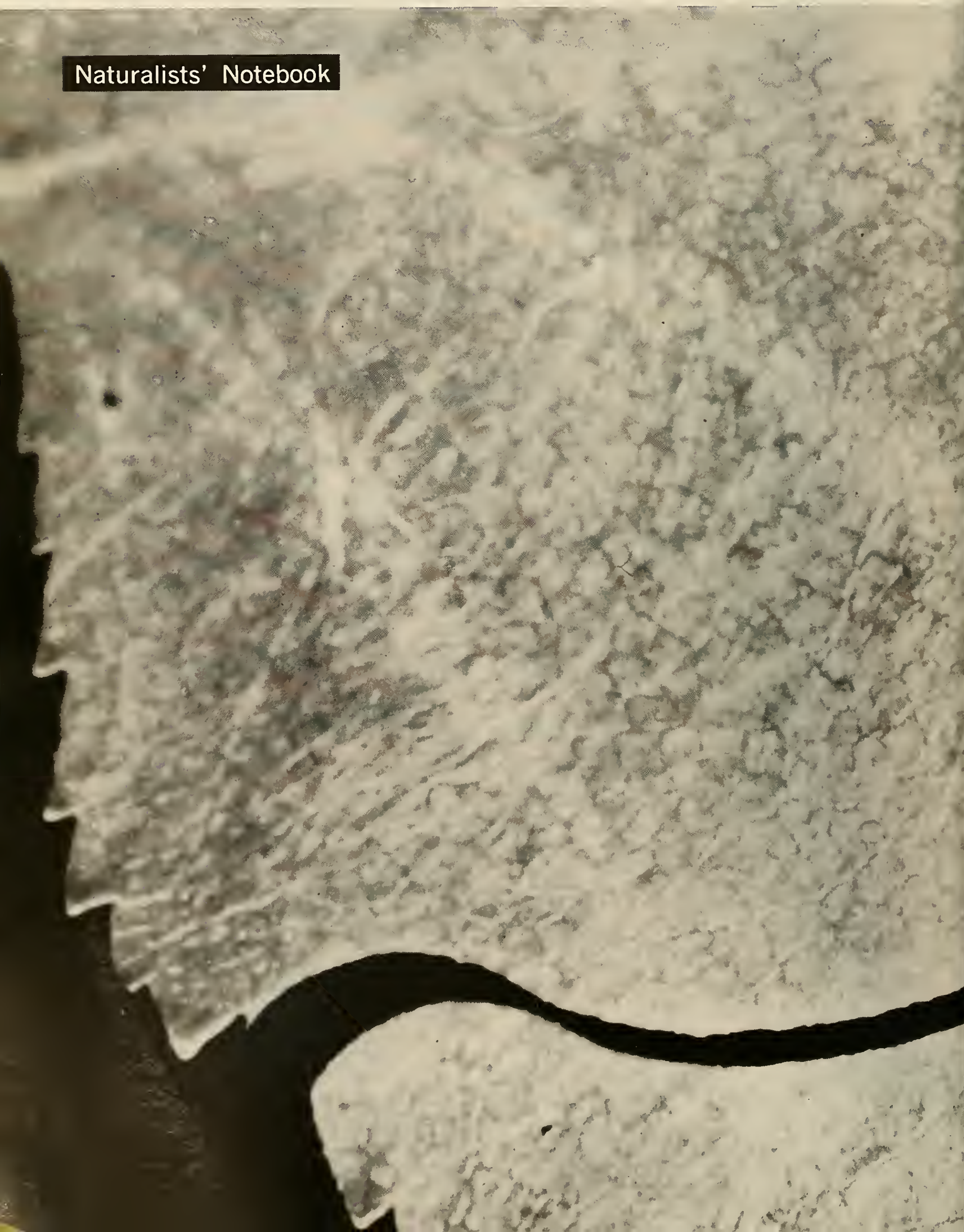
As far as dinosaurs are concerned, Marsh was clearly the winner. He collected more and described more than did Cope—perhaps because Cope's interests were wider than Marsh's. Cope had a greater variety of fossils to study than did Marsh, and, in addition, he was studying and publishing on recent fishes, amphibians, and reptiles. The score: Marsh described nineteen genera of dinosaurs; Cope only nine.

The work of Marsh and Cope amazed and overwhelmed paleontologists in Europe and in other parts of the world. These two willful, determined men expanded the knowledge of dinosaurs from scattered descriptions, based largely upon parts of skeletons or isolated bones, to a large body of scholarship founded upon an imposing and varied array of skulls and relatively complete skeletons.

Dinosaur evolution as related to the extinct and living reptiles—as well as to birds—is shown in this family tree.

CROCODILIA
BIRDS
RHYNCHOCEPHALIA
SQUAMATA
CHELONIA
TERYGIA
SAURISCHIA
ORNITHISCHIA
PTEROSAURIA
THECODONTIA
COTYLOSAURIA
THERAPSID
EOSUCHIA
PELYCOSAURIA
MESOSAURIA

CONVERSION OF A LEAF



weevil rolls conical cases for its eggs

By Jerome G. Rozen, Jr.

The largest family of living creatures comprises 40,000 described weevil species, of which the birch leaf roller, *Deporaas betulae* (Linnaeus), displays some of the most interesting and most studied habits. The home that this shiny black beetle, less than a quarter-inch long, builds for its offspring might well interest anyone concerned with insect behavior, mathematics, or origami, the Japanese art of folded paper construction.

On warm spring days the female birch leaf roller, finding a tender leaf on its host plant, crawls onto the upper or lower surface of the blade and begins cutting a smooth, S-shaped incision near the base, from the outer leaf margin to the midrib. She bites the midrib, not severing it, and starts a new incision on the other side of the vein. This cut, less sinuous than the first, extends to the far margin. The leaf blade is now divided into a small basal part attached to the petiole, and a much larger apical section suspended only by the weakened midrib. Returning to the starting point, the beetle places herself on the underside of the apical section and with her legs rolls half of it into a slender cone. The finished cone consists of five to seven rolls, and lies next to the midrib. The insect then wraps the other half of the section around the cone several times in the opposite direction. Thus, the completed case has an inner core made of the first half of the leaf and an outer, protective layer formed of the second half. The arresting mathematical aspect of the cone construction is that the serpentine incisions are the ideal geometric shape to minimize the work needed to roll the leaf halves and prevent their uncoiling.

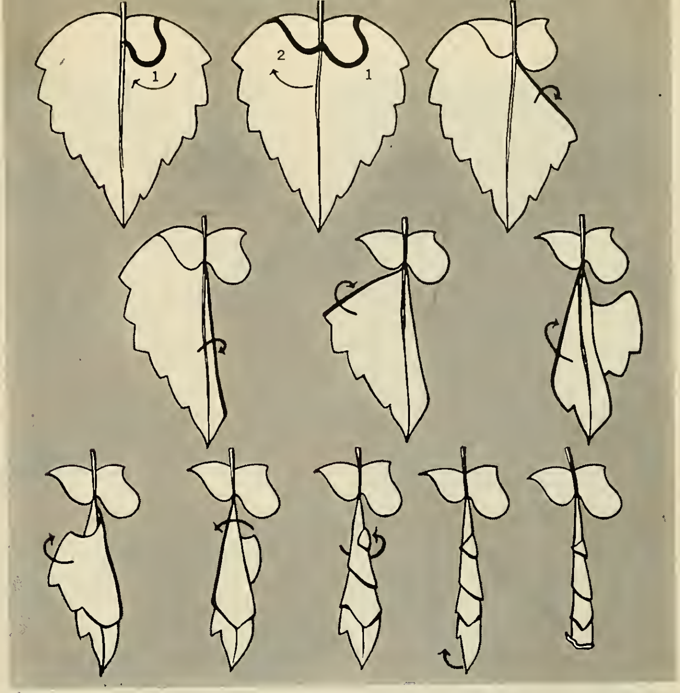
The female weevil enters the open, conical case, chews three to five slits in the lower epidermis of the leaf-half forming the inner core, and inserts a yellowish, oval egg into each. Emerging, she makes a second, small cone at the tip of the leaf and folds it across the opening, completely incasing the brood. The whole task takes about an hour. The weevil then sets out to find another leaf to roll.

Within the rolled leaf, the eggs develop into small, whitish, legless larvae that, over several months, consume most of the inner core of the drying leaf. As a result of rain and wind, the

Birch leaf roller makes initial cut in leaf from edge, working to midrib.

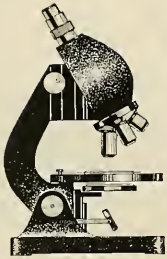
ses occasionally fall to the ground. t whether high on the tree or on ground, the completely fed larvae aw through the brood chamber and op to earth, in which each constructs smooth-walled pupal chamber and mpletes its life cycle.

The birch leaf roller is found only Europe, where it attacks birch, ha-l, hornbeam, alder, and beech trees. the United States, there is only one ecies of *Deporaus*, and it is limited the western part of the country. Un-rtunately, nothing is known of the ology of this small, shiny, dark blue eevil. However, it may possess bi-rre traits similar to those of its uropean relative, for the genus *Depo-us* belongs to a small group of wee-ls, the Rhynchitini, members of hich often construct odd-shaped ood pouches from leaves. Although one of the other pouches involves the ometrically ideal, S-shaped curve oduced by the birch leaf roller, the usual shapes of the pouches can be ghly characteristic of the species.



WHOLE PROCESS of cutting and rolling birch leaf into a conical egg case is shown in the above sequence sketches. Beetle finishes task in about an hour.

COMPLETED CASE, at left, is still supported by the weakened midrib. Female weevil, on basal part of leaf, has already deposited eggs inside and sealed the tip. Rain or wind may cause case to drop to ground, *above*, before larvae emerge.



NATURE and the MICROSCOPE

Anatomy of the instrument

By Julian D. Corrington

BECAUSE THE MICROSCOPE is a tool, a means to an end, it follows that the quality of the results to be achieved in any specimen study will depend, in part, on the ability of the operator to use his instrument effectively. There are proper and improper methods, and it is especially important for the beginner that he learn correct usage from the start. Even some of those who have been using the microscope for a number of years may find that practices could be improved or that points have been overlooked.

First comes the anatomical side of the picture: learning the parts of the microscope and how and why this ingenious instrument has been put together in the way we find it today—a highly perfected, modern appliance. Second is the functional side: what each part is designed to do for the ultimate purpose of presenting a first-class magnified image of a desired object. Third is operational procedure: how to get the most out of the instrument; care of the microscope and of the eyes; routine laboratory practice.

It is necessary to learn the names of microscope parts if we are to discuss them. The base is horseshoe-shaped and is a heavy single casting to provide stability. Remove the eyepiece and turn the instrument upside down, and you will see that it does not rest on the entire base but only upon two toes and a heel—the same principle as a tripod. Stand the microscope upright and replace the eyepiece. Rising from the base is the pillar and at the top of this is the inclination joint, which permits tilting of the scope. Place the heel of the left hand upon the left fork of the base and grasp the arm of the instrument with the right hand. Pull backward to tilt the instrument. This inclination joint should work fairly stiffly, to maintain any desired angle, but the tension may be corrected with a key supplied on request by the manufacturer.

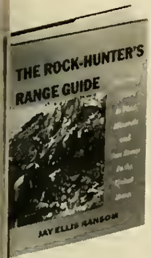
Above the inclination joint rises the arm, and at its lower end is the stage, usually a square, horizontal platform upon which the specimen slide is held by two spring clips. Remove and replace these clips and note their construction. Centered in the stage is the aperture, a circular opening through which light must pass to illuminate the object. Any items below the stage are designated the substage, which includes a mirror, a diaphragm and, sometimes, a condens

The mirror usually has two surfac one plane and the other concave, mou ed in a circular mirror frame. This me band has two small, opposite holes tl engage with detents (tiny raised knob on the mirror fork. This, in turn, swiv on the pillar or on a separate mirror ar which moves on the pillar as a pendulu Remove the mirror and note how it held, then replace it. To do this, the fo may be sprung apart slightly by pulli on one of its arms with one hand wh holding the mirror frame with the oth The mirror may be revolved, twist swung aside; this permits placing surface at any desired angle when in u

THE condenser, when present, is tually a separate microscope, of t or more elements, designed to focus in dent light rays upon the specimen. has an adjustment knob to raise or low and is essential when an oil-immersi objective is used. In most models it is separable Abbe condenser, the top e ment of which can be removed, alteri the condenser's focus and field.

Located below the condenser or, none is present, just below the stage the diaphragm, which may be one of t types. The disk diaphragm is a circu metal plate with a series of holes of creasing diameter. It can be revolved that various-sized openings come in line beneath the stage aperture, contr ling the diameter of the cone of lig admitted to the specimen, and hence t luminosity, which ranges from bright dim. The iris diaphragm—named fro the iris, a sphincter muscle of the e that regulates the diameter of the pupi varies from wide open to almost clos like the diaphragm on a camera. It co sists of a number of curved, overlappin thin metal plates and, while preferred the disk type in the better instrumen is more expensive and more eas damaged. Below the condenser there i slot for the insertion of various fil disks, such as a daylight blue disk tl transmits light simulating sunlight.

Rising above the stage is the curv arm that supports the body of the mic scope and is shaped for convenience carrying the instrument. Use the fi second, and third fingers of the rig hand to grasp the arm, and support t



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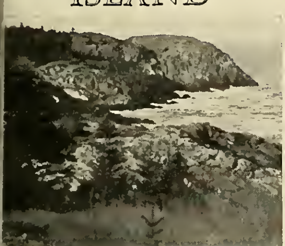

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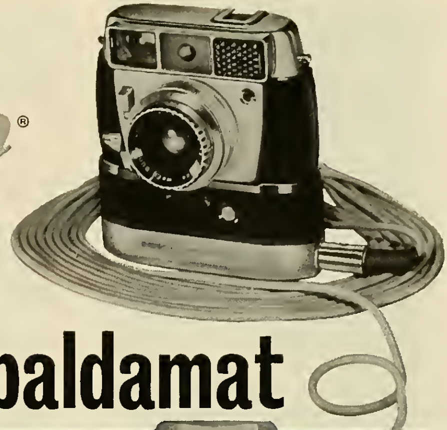

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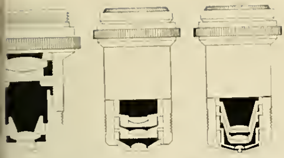
base with the palm of the left hand w transporting the microscope from pl to place, maintaining it in a vertical p tion. On the arm of most models are pairs of vertical knurled wheels. larger are the coarse adjustment kn that, when turned, move the body rapi up or down for approximate focusi the smaller are the fine adjustment kn that move the body very slightly for ex focusing. In certain newer instrume this adjustment is located at the base the pillar, so that the hand that actua it may rest on the table.

PROJECTING forward from the arm the body, or tube, a cylindrical p tion of the instrument that carries optical elements. Remove the eyepi and grasp the tube with the palm a fingers of the left hand. With the ri hand operating the coarse adjustme raise the body as far as it will go a keep right on pulling upward with left hand so that the body comes fr Place it on the table. That part of microscope minus the tube, as now p sented, is the stand. Look into that p of the arm that faces the stage, and n the two finely polished ways on whi the tube slides. Between them is a spir toothed gear, which is actuated by t coarse adjustment. This is the pini gear. Turn the coarse adjustment kn first in one direction then the other, a watch the gear's action. Now observe t long metal strip on the body that mes with the pinion gear and note that t cogs are cut on a bias. It is easy visualize how a turning of the adju ment knob, with the spiral teeth fitti into the oblique grooves, will serve raise or lower the tube. This strip on t body is the rack. The meshing of ra and gear constitutes an example of great invention of centuries past, t rack and pinion gear, by means of whi motion in one plane is translated motion in another plane—in this ca from rotary to vertical. This form of ge is widely used in many kinds of m chines. Replace the tube, using care start it on its ways correctly, and avo force. As soon as the tube is seate movement of the coarse adjustment w run it down to the proper level. Repla the eyepiece. In the language of the n croscopist, one speaks of "racking t tube down (or up)" for movements the coarse adjustment. On most mode instruments the tube can be racked do only so far, the movement being halt by a metal plate at the top of the tu This safety device prevents the carel crashing of an objective into a slide the top element of the condenser.

At the bottom of the tube is a circul obliquely projecting metal part call the nosepiece. This is a mechanical c sign to seat the objectives and enable t operator to change from one power



ɪᴏɴᴀʟ views of three objectives show: ft. 10X, center, 43X, and right, 97X.

her, and at the same time to protect e objectives not in use from dust. central screw is set at an angle to ube, as a turrethead. The click of a nt announces that an objective is ectly seated on the optical axis of the roscope. Nosepieces are designated ouble, triple, or quadruple, according to the number of objectives.

xcept for the mirror, all of the items far considered are collectively referred to as the mechanical parts of the roscope. They are non-essential, but designed for ease of operation. With the modern design of these parts, ipulation of the microscope of today ld be awkward indeed. They have n refined through the last three hun d years, constantly increasing in iency and simplicity.

ʜᴇ optical parts comprise the mirror (removed if the lamp is placed dily beneath the stage), condenser (if sent), objective, and eyepiece, the two always present and essential. primary requirements for presenta of a magnified image are the object, microscope, and the observer. That ical part nearest the object is there e termed the objective, while that rest the eye of the observer is the piece, or ocular.

The simpler microscope is equipped with two objectives, mounted on a double nosepiece. The shorter of the two is the low power (10X), and the longer is the high power (43X). More advanced (and more expensive) models add a third objective, using a triple nosepiece—the oil immersion (97X). In this case, the 43X is commonly termed the "high dry," since it is not immersed when in use, and the 10X is the "finder," because it is used to locate the general features of the object before turning to higher powers. As has been noted, a condenser is necessary with an oil-immersion objective.

Note the illustration of the construction of the objectives, above, seen in sectional view. The low power has two lenses, a biconvex and a plano-concave, cemented together at the bottom of the housing, and the same kinds, but of larger size, in the upper pair. The uninitiated refer to the whole assembly as a "lens," as in such expressions as the "low-power lens," or a "camera lens." But a moment's analysis will show the fallacy of such usage. The word lens is from the Latin for lentil, alluding to the shape of a biconvex lens that resembles a lentil seed. In the 10X objective there are actually four distinct lenses, and it is therefore incorrect to refer to the whole, or to either the upper or the lower halves, as a "lens." Clearly, some additional terminology is in order. First, take the case of the two upper lenses. Since the two are cemented together to act as a combined refracting unit, they are referred to as a doublet; and so also with the bottom two lenses. But these upper and lower doublets work together in producing the real image, and hence each is an element of the whole assembly, and each lens in an element is a component. Thus, in the 10X or low-power objective, beginning at the top, we have a biconvex lens

and a plano-concave lens, each bein component and together comprising element. Since made of two lenses, t element is a doublet; other types of e ments with more component lenses n be triplets, quadruplets, or even higl assemblies. These statements also h true of the lower two lenses—a seco element of two components. The rangement of four lenses as two e ments, upper and lower, makes objective. Construction is similar in p tographic instruments. The high dry a oil-immersion objectives show an creasing complexity in number of co ponents and elements, and there a types with still more of these unit pa From this description it must be evid that cost rises with the number of lens

The illustration also shows that ea element is held in correct position be exactly centered on the optical a by screw threads, dividing the whole b rel of the objective into compartmen each of which is a cell. These thread metal cells must be tooled to an exce ing fineness of tolerance and the cent tion must be done by expert craftsm

In most modern instruments the lo power (10X) objective is separable. the one available to the reader is such will unscrew at the middle, and you m remove the front combination (lower-e ment), leaving the remainder attach to the nosepiece. This separates the t doublets, and the rear combination (per element) will now act as an object of 4X, a most useful magnification wh examining relatively large objects.

The low-power objective is furt designated as 16 mm., which descri its equivalent focus, and means that of the components acting together fo at the same point as would a single l of 16 mm. focal length. Each compon has its own focal length, but they m

ı. CORRINGTON'S column appeared
gularly in NATURE Magazine for
arly twenty years, and can now be
llowed in the combined magazines.

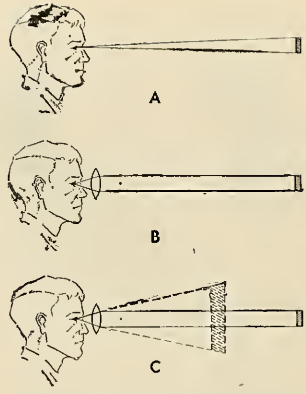
n concert to produce a single image—
e the phrase "equivalent focus," or
The high dry objective has E.F.
n.; oil immersion has E.F. 1.8 mm.
final bit of information engraved on
barrel of an objective is a figure
cating its numerical aperture (N.A.)
25 for the 10X, 0.65 for the 43X, and
for the 97X, the meaning of which
be explained shortly.

ll objectives made today for use
any instrument—microscope, tele-
e, camera—other than a cheap toy
corrected for inherent defects, some
n number. Those corrected to a de-
sufficient for all ordinary purposes
termed achromatic; those corrected
higher perfection for research work
professional photomicrography at
high magnification are apochro-
ic. Most lenses are of glass, but some-
s the mineral fluorite is used, yield-
a semiapochromatic objective.

ow examine the eyepiece of your
roscope. Various magnifying pow-
are available, as 5X, 7.5X, 10X,
X, 15X and 20X and, for projection,
number 0, which is 1X. The two most
monly supplied by manufacturer
n you purchase a new instrument are
5X and 10X. The upper lens is the
lens and the lower one the field lens.
crew each of these and remove them.
e that each is a single plano-convex
, with the convex surface facing
nward, and that the field lens is much
er in diameter than the eye lens. An
piece designed in this fashion is a
genian eyepiece, named after its in-
tor, Christiaan Huygens, a famous
nteenth-century Dutch physicist and
mathematician. Wide-field eyepieces are preferable, but somewhat more costly.

The barrel of a Huygenian eyepiece reveals an annular metal platform extending partly across the interior at about its middle. This is the eyepiece diaphragm. It is here that the real image formed by the objective, plus the field lens of the eyepiece, is located. The diaphragm also cuts out marginal rays, improving the definition of the image. A real image has a real existence. It is an aerial image, hanging in space, and is there whether or not an observer is present to scan it. It may be photographed or projected. It represents a point-for-point reproduction of detail in the object, enlarged by refraction through the objective lenses and by diffraction of the incident light waves around the fine detail of the object. This image is now viewed through the eye lens. This is precisely as if one saw the real image by using a simple magnifier held in the hand, as when we look at a postage stamp or an insect through a hand lens. The eye lens is used to make a further enlargement of the real image; it is one microscope on top of another, hence the term "compound microscope." But the image so obtained is an optical illusion and has no real existence at all; it does not hang in space and cannot be projected or photographed. It requires the presence of an observer whose mind interprets what is seen as a picture situated at the near point, ten inches below the level of the eye—a little below the level of the stage. It is obvious that no light rays go to such a place at all, and so what we see is a virtual image.

The illustration (page 68) will serve to explain what happens. When we scan an object with the unaided eye (A), the angle at the eye made by lines drawn to the two extremes of the object is the



visual angle. Unless this angle is equal to or greater than one minute of arc—1/21,600 of a circumference—we shall not be able to resolve the two extreme points as two, and the object will appear merely as a point. In astronomy, for example, we may have two stars, one near and the other remote, both almost exactly along the same line of sight from earth. Unless their apparent divergence is equal to or greater than one minute of arc, the two will not be resolved but will be seen as a single, blurred object. In microscopy, if an object contains a great deal of fine detail, it is the resolving power, not the magnifying power of the objective, that will permit separation of this detail in the image.

By placing a lens before the eye (B), the incident rays of light are refracted inward so markedly as to increase the visual angle. An enlarged real image, or retinal image, is formed on the sensitive cells of the inner coat of the eye. The mind now interprets these bent rays of light at their face value, and projects them outward into space to the near point as straight lines (C), thereby obtaining the virtual image of the object. It is obvious from the figure (C) that no actual light rays proceed outward to the near point, and hence the image is virtual. All observations through optical instruments are of this class.

With this background we may draw certain further conclusi Magnification alone is not enough ir optical instrument. It will be useles enlarge an image unless we can ther see greater detail in the reproduc of the object. One might ask, since have placed one microscope on top another in the compound instrum why a third lens should not be emplo above the first two, thereby gaining greater enlargement. The answer is t the image we would attempt to enla is not there; it is a virtual image. can make a photograph through the croscope by focusing a real image on film and then enlarging the print. could then project this print onto distant screen, further increasing magnification to a gigantic size. But amount of such enlargement will sl any more detail than is present in small, real image in the first place. can make a bacillus appear as big a balloon, but will see no further de thereby. This is empty magnification a is therefore useless.

Resolution, or the ability of an obj tive to reveal fine detail, is a more portant property than magnificati though we must have both. A finely b and corrected objective will have a mu higher resolving power than will a cru one, and of course the required wo manship makes it much more costly. fact, since this matter is importa enough to be dealt with in some det we shall wait for a later installment discuss in detail the mathematics t are involved in measuring the resolv power of various types of objectives

This list details the photographer, art or other source of illustration, by pa

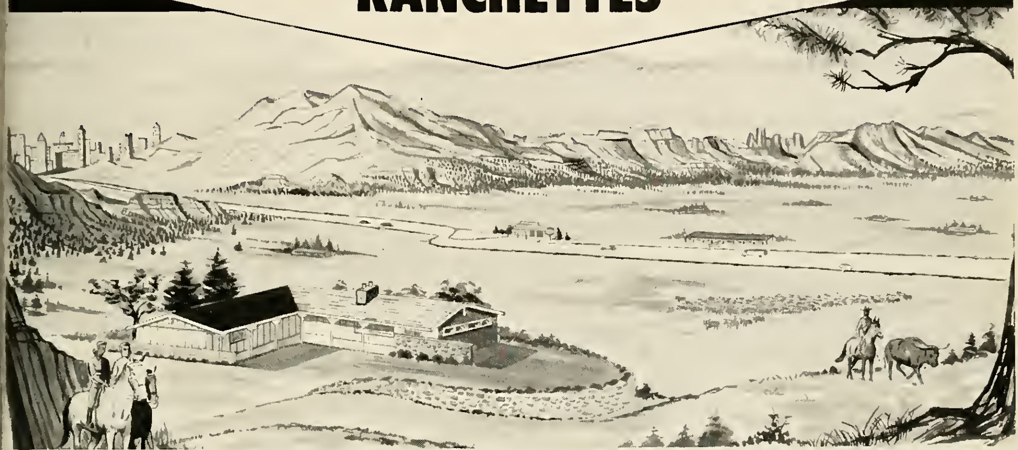
COVER—Lee Boltin
3-4—Joseph Sedacca
8-19—Lee Boltin, except
8-bot., Alexander Klots
20-29—Hans Guggenheim
30-31—AMNH after
Grabau
32-33—AMNH after
Koppen and Wegener
34-35—AMNH after Creer,
Irving, and Runcorn
36-37—top, AMNH after
Owen; bot., after Ma
38-39—AMNH after
Durham
41-43—Walter Dawn
44—© California Insti-
tute of Technology
46-47—Sky Map after
Henry M. Neely
48—AMNH Archives
49—Illus. London News
50-51—Trustees of the
British Museum
52-53—AMNH Archives
54-55—top, Peabody
Museum, Yale Univ.; bo
U. S. Geological Survey
56-57—AMNH
58-61—Sune Berkeman,
from Black Star except
61-top, AMNH after Deb
65—AMNH
68—AMNH

On U.S. Route 66 — Only 39 Miles from America's 7th Fastest Growing City

ALBUQUERQUE, NEW MEXICO . . .

An Acre of Your Own in

THE VALLEY OF THE ESTANCIA RANCHETTES



FULL ACRE FULL PRICE $395

ONLY $10 DOWN A MONTH

Suddenly — almost without warning — the land boom is on in New Mexico. All at once Americans have discovered the "Land of Enchantment". . . and homes and ranchettes are springing up on lush verdant tracts which until now were enormous ranches.

And especially is this true of the lovely valleys surrounding Albuquerque, the queen of New Mexico. This exciting city is bursting at the seams and homes are spilling out in all directions. Albuquerque has become America's "7th fastest growing city" — and is picking up speed at an astounding tempo.

Astounding? Please consider: In 1940 Albuquerque had less than 36,000 people. By 1950 it had soared to 97,000. And in the last 10 years it has rocketed to more than 260,000!

There are so many reasons for this fantastic rate of growth. Nowhere in America is there land more beautiful than the rich valleys that rim Albuquerque. The **climate** is possibly without equal in all of America — a summertime of balmy sunny days* and bracing nights — blanket-sleeping nights; and in the winter equally sunny days* — shirt-sleeve weather. **Health?** This is a region whose mildness and purity of climate have given new life to people from all parts of our land — where, in respiratory ailments alone, thousands of cures have been miraculously achieved by the mild weather, the dry air, the abundant sunshine, the low humidity. In the words of the Encyclopedia Brittanica the Albuquerque region is **"a health resort"!** And what about **sports, entertainment, activities, opportunity?** In the lofty close-by mountains are fishing, swimming, hunting. Skiers wear shorts. Golf is played the year 'round. Albuquerque itself is crammed with magnificent shops, theatres, churches, schools — including the University of New Mexico with 7000 enrolled students, bright new college buildings and modern football stadium. Albuquerque has the 5th busiest airport in the United States. Its industry and employment potential are boundless. Its 3 television channels and 9 radio stations, its opportunties in land ownership, jobs, small business; its sunniness, its freshness and sparkle — all of these mark the personality of a great city.

The wonder is not that Albuquerque is growing so rapidly. The wonder is that one can still buy a lovely piece of land close to the city at so low a price as $395 an acre! All you have to do is to take a look at the six cities which in all of America have grown even faster than Albuquerque. **What would you have to pay for an acre of comparable land only 39 miles from their shops and theaters?**

(THESE FIGURES INCLUDE OUTSIDE CENTRAL CITY)

	Population	Rate of Rise 1950-1960	Cost Per Acre of Comparable Land 39 Miles from Downtown
1. San Jose, Calif.	639,615	120.1%	$2,500 – $ 5,000
2. Phoenix, Arizona	652,032	96.5	$3,500 – $ 7,000
3. Tucson, Arizona	262,139	85.6	$1,500 – $ 3,000
4. Miami, Florida	917,851	85.4	$5,000 – $10,000
5. Sacramento, Cal.	500,719	80.7	$2,000
6. San Diego, Cal.	1,003,522	80.2	$4,000 – $ 8,000
7. Albuquerque, N. M.	**260,318**	**78.7**	$395 (Valley of The Estancia Ranchettes)

* *Last year for example, there were only 8 days that were not sunny.*

These statistics are eye-openers, aren't they? **Yet real estate men are saying that the prices you have just read will soon apply to the Albuquerque region!**

And as lovely and luxuriant an area as Albuquerque can boast is **The Valley of the Estancia Ranchettes.** Rimmed by mountains, lying flush alongside the most important highway in the West, Route 66, and only 39 miles from Albuquerque, **The Valley of the Estancia Ranchettes** is the essence of the enchanting Southwest. Please read this carefully! **The Valley of the Estancia Ranchettes are not barren desert tracts. They are lush and green!** Water waits to be tapped. The soil is so fertile as to bear fruit trees and truck gardens. Our Route 66 neighbors frame the landscape with their low modern ranchettes, homes, motels. Our next door neighbor is the famed $200,000 Longhorn Museum of the Old West . . . Oh yes, this is a very lovely land.

As our headline says, an acre in our beautiful VALLEY OF THE ESTANCIA RANCHETTES costs $395 **complete!** And the terms are $10 down and $10 a month per acre. That's it — no extras, no hidden additional costs. You may reserve as many acres as you wish. AND YOU TAKE NO RISK IN SENDING YOUR $10 TO RESERVE YOUR ONE ACRE RANCHETTE SITE. Your $10 reserves an acre for you, but you have the unqualified right to change your mind. As soon as we receive your reservation we will send you your Purchase Agreement and Property Owner's Kit. The package will show you exactly where your property is and will include full maps, photographs and complete information about your property. Other maps will show you nearby Arizona — even old Mexico itself, 250 miles away. You may have a full 30 day period to go through this fascinating portfolio, check our references, talk it over with your family. If during that time you should wish to change your mind (and you don't have to give a reason either) your reservation deposit will be instantly refunded. (ALBUQUERQUE BANK REFERENCES).

Experienced realtors think that the Albuquerque area presents the most exciting acreage buy in America. On the outskirts of the city, land is now going for $5000 to $6000 an acre. One day soon the Valley of the Estancia Ranchettes could be a suburb of Albuquerque. Act now. You'll be forever grateful that you did.

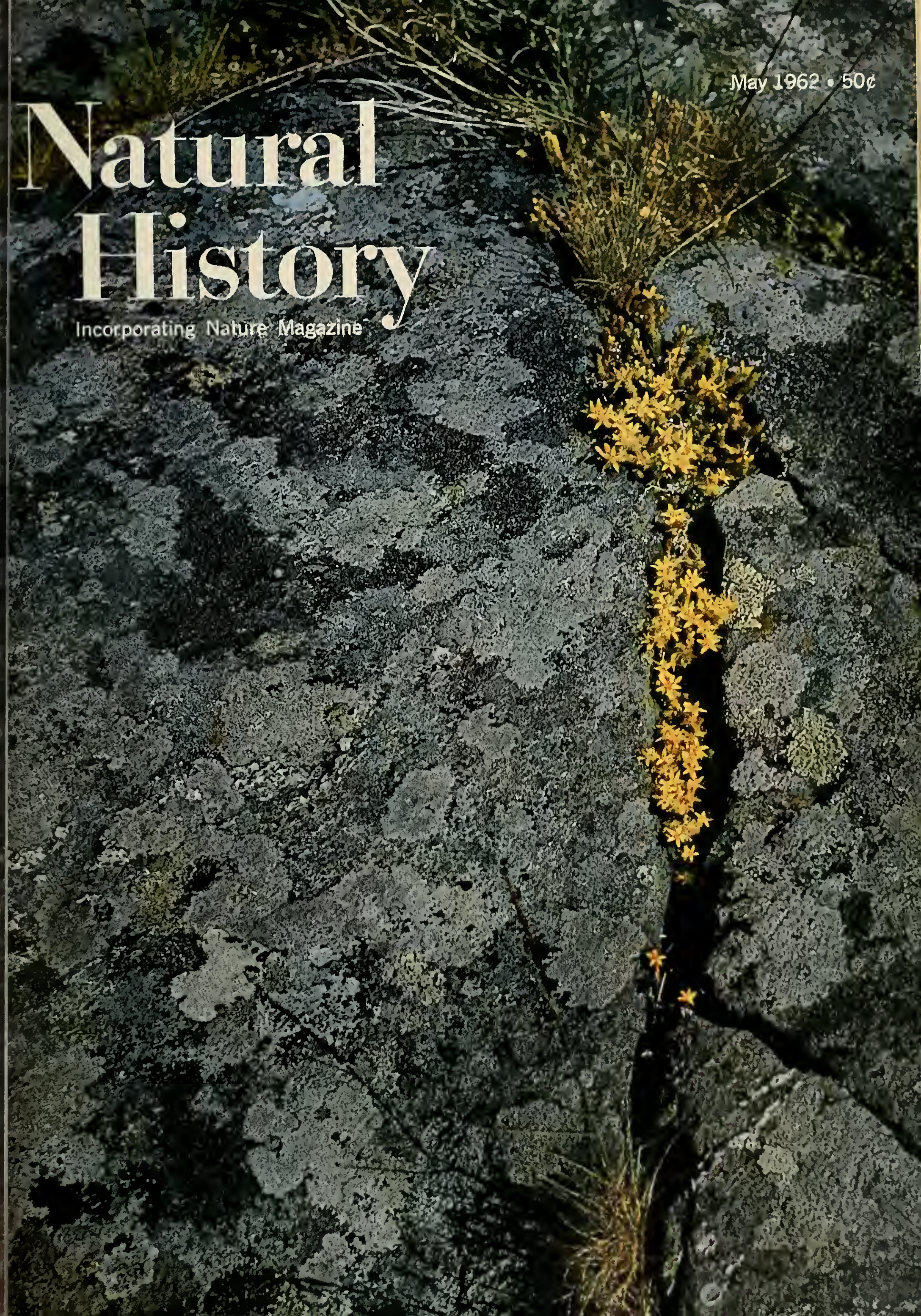
VALLEY OF THE ESTANCIA RANCHETTES
Dept. L-68
2316 CENTRAL S.E., ALBUQUERQUE, NEW MEXICO

Gentlemen: I wish to reserve ________ acres in the VALLEY OF THE ESTANCIA RANCHETTES. I enclose a deposit of $________. (Please send deposit of $10 for each $395 acre you reserve.) Please rush complete details, including my Purchaser's Agreement, Property Owner's Kit, maps, photographs, and all data. It is strictly understood that I may change my mind within 30 days for any reason and that my deposit will be fully and instantly refunded if I do.

Name________________________________

Address________________________________

City________________ Zone________ State________


May 1962 • 50¢
Natural History
Incorporating Nature Magazine

Reviews

Diverse approaches to "popular" anthropology

By Colin M. Turnbull

The Heart of the Hunter, by Laurens van der Post. *William Morrow, $4.50; 268 pp., illus.* It Began in Babel, by Herbert Wendt. *Houghton Mifflin Co. $6.50; 444 pp., illus.*

In the past four years several popular books have been written about the Bushmen of the Kalahari Desert in southwest Africa. Laurens van der Post has accounted for two of these works: *The Lost World of the Kalahari* and its sequel, *The Heart of the Hunter.*

In the first work, van der Post writes of his search in the desert for the people of his childhood dreams, and if the book is more about the search than the people, it is nonetheless interesting. The physical journey into the Kalahari over, the author finds himself faced with an even more difficult and exciting journey—a journey of the mind. And so in *The Heart of the Hunter* he picks up the story and states his position clearly. He does not feel qualified to write as a scholar, nor does he want to. He says: "All I can claim is to have had a perhaps unique experience and the right to try and communicate, not knowledge, but the experience itself. I hope I have learned by now, the danger and futility of trying to improve on one's own truth."

We are then taken on a tour into the inner world of the Bushman, and begin to see with Bushman eyes. The vehicle for this splendid journey is composed of the legends and dreams of the Bushmen themselves, and when we emerge the whole world looks different. The sands of the desert, its hidden waters and fruits, every living thing upon it—all have new meaning. The sun and the moon, the wind and the rain, are no longer what we thought them to be.

Nor do we have to trust entirely to the wisdom of van der Post's interpretations. He gives us the facts and we can do what we like with them. He tells us what they mean to him, and in view of his unique experience and his ability to detach himself from his subject as readily as he becomes attached, we would do well to consider his opinions carefully. Experience is not scientifically conclusive, but van der Post has done a great service by offering a more than reasonable springboard for further scientific inquiry. This is no small achievement, but perhaps an even greater one is the opening up of this new world to the intelligent and sensitive layman. Even trying to summarize *The Heart of the Hunter* would be to do it a great disservice. It should be read from cover to cover—preferably, though not essentially, after reading *The Lost World of the Kalahari.*

It is often said that scientific accounts should be free from any personal emotion and personal involvement. Laurens van der Post does not set out to write scientific accounts; but even if he had done so, both his emotions and his involvement would have stood him in good stead. Not being bound by rigid scientific methodology, he is able to jump headlong into the realm of emotion and belief, and he does so with insight and wisdom.

In conclusion, it is worth noting that van der Post is writing about a people of his native land. From earliest childhood he heard Bushmen's tales from their own lips and from the lips of his grandfather, who knew them before they were driven into the remotest regions of the Kalahari by a relentless civilization. The author is profoundly concerned with what civilization is doing to these remarkable people, and his book is in the nature of a criticism of his own people and their blindness to the really true and great values of life. *The Heart of the Hunter* is not only an enchanting book, it is an important one, and it has meaning for all of us in our own troubled world, so unlike that of the Kalahari.

Popular books are being published with increasing frequency in the field of anthropology, and seem to be produced to meet an increasing interest on the part of the buying public. But the results of this "popularization" are not always as successful as van der Post's.

It Began in Babel is the title of a singularly unattractive book by Herbert Wendt, who attempts to delve into the somewhat cloudy waters of the origins of mankind. It has an apt title, as the author's inept, inaccurate, and frequently unintelligible voice only adds

f ther to the confusion. and leads the r der to wish that it had ended in Babel. Throughout, Wendt deplores "pseudo-entists," yet in his "Acknowledge-r nts" he pretentiously thanks "special-ts of all kinds" and "the ethnologists, theologists and students of civilization, biologists and anthropologists. direc-t s of museums and the librarians from iom I learnt so much. . . ." He then inages to mention the names of Mar-ret Mead. Ruth Benedict, and the Fro-nius Institute and implies that they are a sense responsible for what is to llow. The bibliography is full of re-wned names, and Mr. Wendt modestly ites that his aim is ". . . to revise and iit together, in all its richness and eadth, the available material."

THIS imposing façade begins to totter as we look at the contents list and id headings such as: "Barbarians and onsters," "Heathens and Slaves," and hen we find that the one reputable-unding heading, "Totem and Taboo" iot very original), covers a section that is nothing to do with either totem or boo. It crumbles significantly when the st of illustrations is checked with the iotographs. The first plate is of Hermes," a marble by Praxiteles, show-g traditional, classic Greek features, it the caption explains that the statue . . shows the facial characteristics hich the Greeks attributed to the 'bar-arians,' their name for all those who ere not Greek." In the course of his searches, Mr. Wendt presumably dis-vered that Hermes was not Greek. And hat of his allusion to the Jutland iummy (plate 26) as "an ancient Ger-ian"? But worse is yet to come. Plate 6 bears the caption: "The Watussi are iasters between the Nile and the Zam-ezi. King Munsa entertained the ex-lorer Schweinfurth in the nineteenth entury." Either the lay public is not xpected to know better. or else this idicates the general level of research one by Mr. Wendt or by his publisher, or the picture is indeed of King Munsa, ut he happened to belong to the Mang-etu tribe. not the Watussi—the latter ieing several hundred miles away and otally unrelated. Even less excusable is Plate 20, whose caption reads: "A sculp-ure of a primitive tribe of Vedda des-ent in India." The object reproduced is, n fact, one of the best-known and most asily identifiable of all African carvings –a funerary mask of the Bakota people.

It is not that Mr. Wendt's facts are all wrong, even though many are demon-strably so. It is rather that, having created exactly the pseudoscientific aura that he decries, he then pontificates upon subjects that are still completely unde-cided and controversial. It is precisely because *It Began in Babel* is so very bad that it needs a review to act as a warn-ing for unwary laymen.

The author begins by using the rather feeble technique of pretending to have been an eyewitness to events that took place hundreds or thousands of years ago. We see Herodotus, in the year 445 B.C., giving a lecture in Athens, with a friendly, slightly ironical smile on his face and. of course, with his eyes twink-ling. The lecture seems to bear out Wendt's personal and condescending ap-proach—that other peoples, even if they do have rather strange customs and seem a bit on the primitive side, are not really so bad once you get to know them. The early writer Galen is criticized for say-ing that ". . . the Negro is characterized by his crinkly hair. meager growth of beard. large nostrils, thick lips, evil body smell and black complexion . . . and is passionately fond of all kinds of games and pleasures." On this we get precisely the kind of comment from Wendt that we might expect: "In the main. these observations are true; there is only a very noticeable disdain in the way Galen puts them together. . . ." But what about Mr. Wendt's reference to the Negritos as " 'little nigger boys'," or his assertion about the African Pygmies: ". . . in one respect the critics of the Pygmy race have told no lies, the forest dwarfs smell abominably!"

There is, however, one excellent quote. It is taken from a Babylonian tablet: "If you really think about it, people on the whole are very stupid."

LET us look for a moment at some of the things that Wendt attributes to unnamed scientists: "Today, most an-thropologists accept that the Boskop race, once so tall and strong and promis-ing, degenerated to the level of the Bush-men—either through climatic influences or by being driven into the desert by more powerful tribes." And with regard to the same Bushmen. now considered together with the Hottentot: "yet so Hamitic do they both look that the majority of experts class them together in the 'Khoi-San racial group.' "

Any anthropologist will demand to know who these "experts" are who talk of "degeneration," or who class peoples together as one race because they "look so Hamitic." It is difficult, even given a good imagination. to see anything Hami-tic in a Bushman. The usual popular trend is to see something Mongoloid. There are some who see scientific grounds for connecting Boskop with present-day Bushmen, but in any case there is no implication of "degenera-tion," which is Wendt's own coloring.

MR. TURNBULL, an ethnologist with THE AMERICAN MUSEUM, is author of *The Forest People*, published last autumn by Simon and Schuster, Inc.

As for his other assertion that this "degeneration" took place "either through climatic influences or by being driven into the desert by more powerful tribes," there are not many reputable scientists who would be as confident as he.

THE author is obsessed by the notion that small peoples are degenerates, and he uses the term "dwarf" and "dwarf race," to imply degeneracy or abnormality. Now we must concede the possibility that the translator, James Kirkup, is at fault here, and in the original German the term might have been *Zwerg Völker* rather than *Zwerg*, the former being better translated "dwarf people" than "dwarf race," although it remains a misnomer. Further, he states: "That isolated human tribes or groups very soon become dwarfs under unfavorable conditions is proved by numerous examples, the best known of which is that of the Vikings of Greenland." One moment he specifically refers to the climate as the cause, and next, when the actual cause of a physiological change (that could hardly be called degeneracy of a normal race into a race of dwarfs) is probably interbreeding rather than climate, he chooses not to be specific. And, of his "numerous examples," this is the only one he troubles to mention.

More examples of "Wendtisms": "Anthropologists refer to the Veddas as 'delicately-built savage types of human being.'" This antiquated language is typical of Wendt, *not* anthropologists.

"The Anthropologists look upon them (the Zande tribe of Africa) as model human beings." Anthropologists are not in the habit of passing judgments of this kind, because such comments have no scientific validity or foundation.

"But the ethnologists apparently found this [the South Sea Islander's horror of incest, adultery, and sexual perversions] only extremely queer and comical." This is going a little too far, for if Wendt had even a small fraction of the respect he says he feels for scientific investigation, he would not present so ridiculous a picture of an anthropologist, nor would he have done so had he understood scientific discipline.

Now, all this leads us to examine Mr. Wendt's several "Acknowledgements" a little more carefully. I am sure that neither Margaret Mead nor the late Ruth Benedict would agree that the customs of the "savages" they studied were "only extremely queer and comical," and the Frobenius Institute must equally be absolved. They are presumably thrown in, with most of the standard works quoted in the bibliography, as window dressing, and there is little evidence of research of any substantial nature.

It is not surprising that, apart from a great many half-truths and errors of omission, there are errors of commission as well. The author devotes much time and space to Africa, although his whole section on the origin of the African Negroes seems to be devoted to saying that they are not African because: "All primitive Africans, ignoring Neanderthal or even older human types, belong broadly speaking to European humanity." Then follows a revealing statement: "A more detailed examination of the complicated system of culture-groups in Africa would take us beyond the bounds of the present work . . . there is no 'real Negro civilization'. . . ."

In the same section, engagingly entitled "Gulliver and the dwarfs," the author states: "All fieldworkers who have visited the Ituri forest assert that they have never seen any poisoned weapons among the pygmies." Later he refers to Martin Gusinde and Paul Schebesta, both of whom have written numerous works on the Ituri Pygmies. In these works, constant references are made to arrows poisoned. There is hardly a single traveler's narrative that does not testify to their use, many museums have them in their collections, and we even know the nature of the poisons.

WENDT also endeavors to explain some rather outdated theories of evolution. Possibly mistaking a recent revival of an interest in Morgan's notions on cultural evolution, Wendt champions the old, disproved notion that a culture has to pass through certain stages of development, moving "from savagery to barbarism." There are recent thoughts that culture as a whole may perhaps follow a general evolutionary pattern, but there is no idea that every individual culture has to do so—there are far too many cases of considerable gaps being bridged by the increasingly rapid process of culture contact. But Mr. Wendt's contention, and this is one of the few original things he has to say, is that the colonial powers in Africa are to be held responsible for arresting ". . . an historical process's normal development." He justifiably criticizes colonial powers in Africa for much that they have done, but the thought that they should have done nothing to lead the African from tribalism to a wider nationalism would not appeal to many Africans. This is, in fact, what has happened in the Congo, with self-evident results.

If I have nothing good to say about the book it is because it is inaccurate, unscientific, and confused. There is a wealth of first-rate material readily available to the popular writer who wants to investigate the subject, but in spite of pretensions of indebtedness to scientists, Wendt seems to have preferred his own individual world of make-believe throughout. The distinction of this book lies in its signal disservice to its subject and to any intelligent reader.

N BRIEF

M WILDERNESS: EAST TO KATAHDIN, b William O. Douglas. *Doubleday & C., $4.95; 290 pp., illus.*

JUSTICE DOUGLAS' second volume of *My Wilderness* is characterized by his ie enthusiastic and open approach to American wilds. It is good to hear n a man who still knows how to walk l to stop for beauty; who knows na- e whether he is in the Great Smokies, zona, Maine, or the C. & O. Canal out Washington, D.C. He is a useful trav- r, for he reminds us all of winds in the es, mountain flowers, rivers where the ut still run; of true wildness in an : in which humans have tamed nature l in which civilized greed and over- indance threaten our natural heritage. may be minor carping, but the pub- ier might have helped this book's le. It is often flat and staccato. And we have to have: "I felt like I was in a sin on top of the world"? It may be glish in use in some circles, but it is t yet good English usage.

.Y. THE YEAR OF THE NEW MOONS, J. Tuzo Wilson. *Alfred A. Knopf, 95; 350 pp., illus.*

THIS book is an extremely interesting roundup of the events of the Inter- tional Geophysical Year by a Cana- in scientist who traveled throughout world during this time. Those who hope for mankind through interna- nal scientific endeavor should be en- uraged after reading of the close col- oration and co-operation among men many nationalities, who combined to ike a new picture of the vastness and ijesty of the earth and the universe. . Wilson's discussion of earthquakes, aciation, radiation, oceanography, an's satellites, and the sun, is relaxed, od-humored, and intelligent. The de- riptions of travel in Russia and China e enlightening because of the traveler's spassionate and sympathetic approach, id his cool, scientific way of looking at e works and its problems.

EETLES, by Ewald Reitter. *G. P. Put- im's Sons, $20.00; 205 pp., illus.*

BEETLES are the largest order of ani- mals on the face of the earth. There e more than four times as many de- ribed species in this group as there are hordates—from *Amphioxus* to *Homo ipiens*. As a result, an author intending compile what is essentially a popular icture book of these creatures is faced ith the difficult task of deciding on what asis he will select some 230 specimens om the 277,000 available species.

Happily, Ewald Reitter decided to portray (with one or two exceptions) the largest and most bizarre forms, not only of coleopterology but of entomology in general. These animals are revealed in larger-than-life colored photographic reproductions. The 60 plates are unquestionably the outstanding feature of the book, for the color reproduction is splendid and subtle, and the beetles are grouped beautifully on each plate.

Since the gaudy beetles are restricted to a mere handful of families, this book is obviously taxonomically unbalanced. However, the pictures admirably persuade the viewer to read the text, a more balanced introduction to the Coleoptera. There, Reiter discusses in terms intended for the non-entomologist, evolutionary beginning, anatomy, ontogenetic development, classification, zoogeography, ecology, body sizes, sexual dimorphism, and relationships with man in his economy and culture. To present all these subjects in 56 pages, even of folio proportions, is a limitation to the author. But Reitter has coped with the problem in good fashion and his book is recommended to everyone, whether or not they are interested in beetles. Even the doubtful may well change their minds after examining the magnificent pictures.

Paradoxically, although the illustrative material receives my highest praise, it also serves as the basis for my most critical remarks. First, while the photographs are beautiful, the line drawings used to demonstrate the anatomy of the adult tiger beetle are mediocre at best. The sclerites are confusingly delineated, the label pointers often end at inappropriate places, and there are several outright errors in the labels. In view of the expense and effort spent on reproducing the color photographs, why was not a little more attention devoted to the simple, inexpensive line drawings? Second, the general reader would better understand and appreciate the section on internal anatomy if line drawings of the major systems had been included. Third, although a single larva—that of a scarab —was shown, the reader is entitled to a photograph, or at least a line drawing, of a beetle egg and of a pupa.

Finally, and this is meant not as a criticism but as an explanation, it would be well for the American reader to keep in mind that the book was written by a European, and was originally drafted in German. It is self-admittedly slanted toward a European audience, in spite of the fact that the specimens depicted are from all parts of the globe. This should help elucidate Reitter's seeming preoccupation with European species, European entomologists, and European entomological institutions.

Wilderness Islands of the North

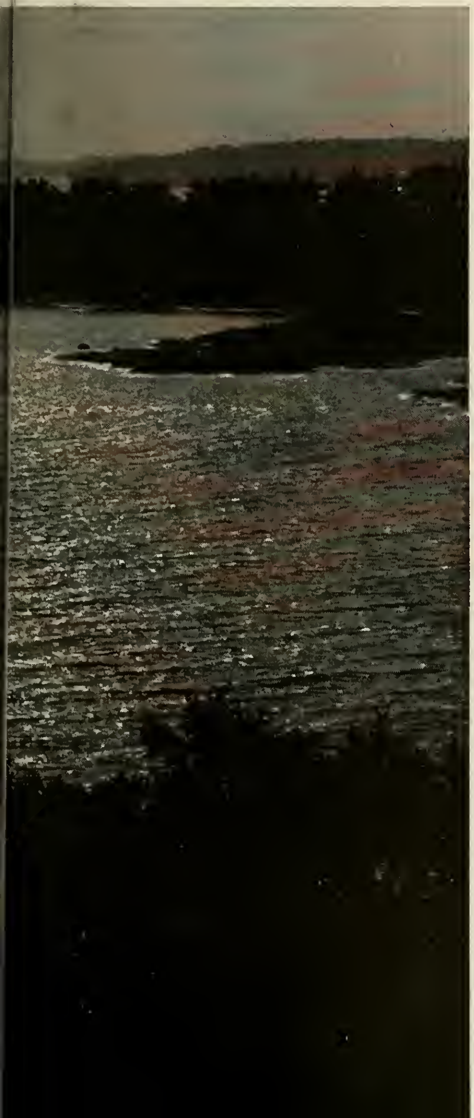
Rising land in the Baltic Sea sustains varied animal life

By Paul L. Errington

NORRTÄLJE SKÄRGÅRDEN is an archipelago that extends eastward into the Baltic Sea from the vicinity of the small Swedish industrial city of Norrtälje. Norrtälje itself lies about fifty miles northeast of Stockholm. For something like 100.000 years much of Scandinavia — including this area — lay crushed under the weight of the last glacial ice sheet. Today, some [illegible]00 years after the melting of this colossal overburden, the land is still springing up at the rate of about a foot and a half each century. It is literally rising out of the sea.

As a visiting biologist, I became acquainted with the Norrtälje area during two spring months spent at Uppsala University's nearby field station on Lake Erken. I was particularly eager to see as much as possible of what remained of the wild in this part of Sweden. Away from the farm lands and villages extend natural woods, rocky hills, bogs, swamps, and lakes—a great deal of only partly tamed wilderness. It is true that the original population of wolves and bears has gone, that many other wilderness life forms are depleted in numbers, and that lumbermen's cuttings and roads invade some of the wildest tracts. Still, the land and water in secluded places continue to represent some of the aspects of the former wilderness.

Here and there, from deep woods to the Baltic shore, can be seen badger "sign"—the long-used dens in rocky crevices, the superficial diggings, the tracks, and the droppings. The large proportion of plant food eaten by these badgers offers a remarkable contrast to the carnivorous and insectivorous



RED FOX stalks through thick spring foliage of an island in the archipelago.

LOOSELY LINKED island chains stretch intermittently to an indistinct horizon.

diet of the North American species.

Beneath the roost trees of the local tawny owl (a relative of our American barred owl) lie castings made up of remains of the same types of small vertebrate prey that a barred owl would be likely to eat under similar conditions. Feeding perches of the tawny owl will also have under them feathers of a small bird. dropped fragments of a mouse or shrew, or egg masses of frogs—discarded in the same way that North American predators commonly discard unrelished items.

Red foxes range the meadows, cutover tracts, and shore zones, leaving their spoor along trails. and bounding away when surprised.

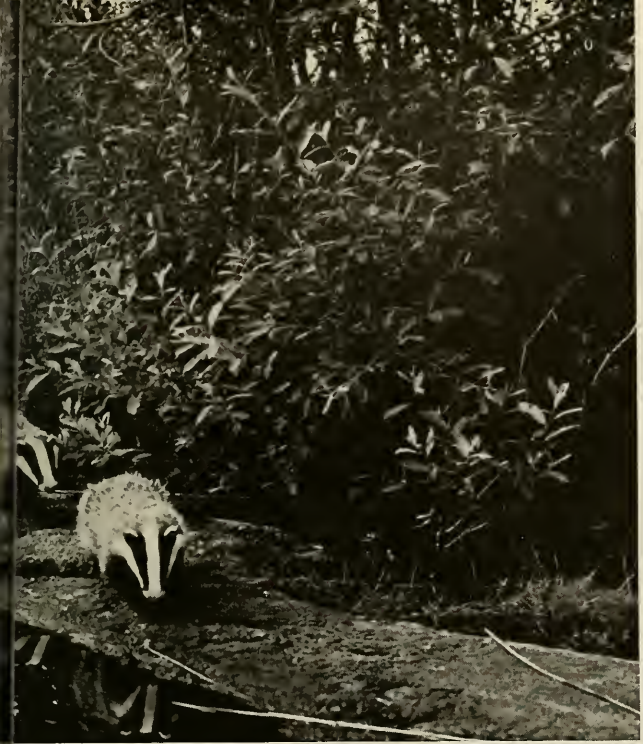
In the woods, the hazel hens—the nearest European equivalent to our ruffed grouse—look and act like our own ruffed grouse. Also sheltered here are big forest grouse. the capercaillie, and droppings made up of pine needles attest to the marvelous digestive system of these birds. Overhead, familiar woodcock dash back and forth in their erratic. mating season flight.

The deeper woodlands, more nearly unbroken, contain forest in which a stranger might become thoroughly lost. Only game trails lead into these depths. Here are the cow-sized hoofprints of moose, and conifers and hardwoods with bitten-off twigs and stripped bark show where the moose had fed. A marten has worked on the forest floor, and in the wet spring snow are lynx tracks.

Many places may remind one of the prehistoric hunters who ranged over land then newly emerged from ice and sea. The Norrtälje area has dozens of Stone Age burial grounds, and the mounds and stone memorials are now high up on banks that must not have been much above the waters of the coastline at the time of the builders. Thoughts of wild human hunters and their prey come easily as one walks ridges and hilltops and peers down through forest growths toward the lakes and bays. It is easy to think of old ice and new land, the slow advances and withdrawals of ice sheets, freezings and meltings, the comings and goings of a subarctic sun over cen-

Mirrored in quiet water, two badgers move along the edge of tangled thicket.

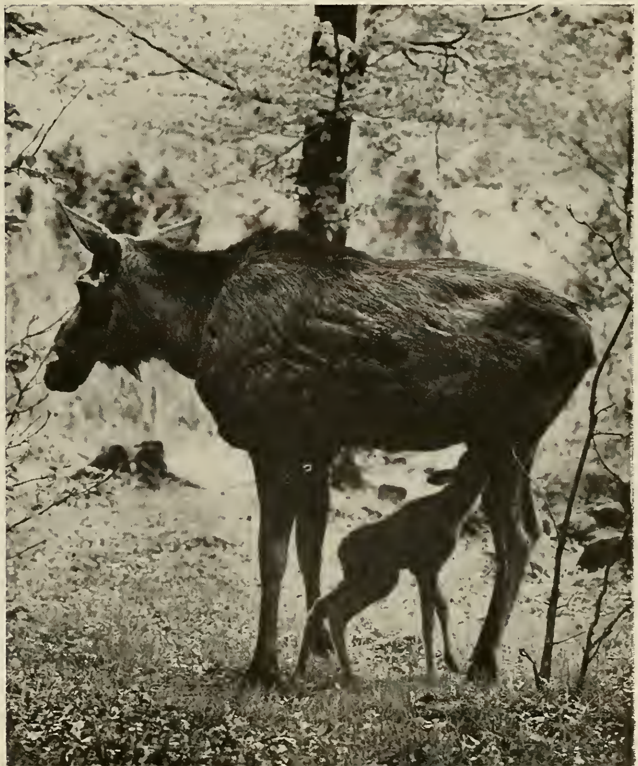
Female lynx, one of area's powerful nighttime predators, devours a bird.



European badger has less carnivorous diet than does North American species.

turies and millenniums, life adjusting again and again, in its own ways, wherever it belonged. It is easy to think of glacial ice as being a part of the Scandinavian scene in its geological manifestations, if not in its immediate presence; it is easy to think of it not being so very far away, at all.

WHENEVER I found myself in a position to look out upon the nearest islands of the Norrtälje Archipelago, I could see that the islands themselves showed evidences of being biotic continuations of the mainland's peninsulas. Both islands and peninsulas hold about the same kinds of living things, or "sign" of living things. Alike, their lower rock tops show the fishbones and scales of otter droppings, fresh and weathered. Buzzard hawks, crows, gulls, crested grebes, goosanders, tufted ducks, a few pochards and scaups, and scattered pairs of mallards are to be seen. There may be mute swans in the reef-fringed waters.



IN A SMALL CLEARING a Swedish moose suckles her wobbly four-day-old calf.

WHEN the archipelago is viewed from the right places, it is seen stretching farther and farther out to sea; wooded islands at first, and then islands with little vegetation on them. In the distance, they look like a broken line, and if one looks out far enough, it is hard to be absolutely sure what is land and what is water.

As guests of a party of ornithologists, my wife and I had our first opportunity to go out onto a Baltic archipelago one sunlit Sunday in the middle of May. In a chartered fishing boat, during one of the rare calm interludes in Norrtälje's spring, we spent nearly all of one whole day.

Our expert fisherman-pilot just kept to a marked navigation channel for an hour or two as we headed outward. The vegetation on the islands that we first passed was chiefly of coniferous or mixed forest. As we went even farther out, the coniferous forest tended to be replaced by hardwoods. Ultimately, not much remained that could be designated as forest at all. There were irregularly distributed hardwood trees, of small size; thickets and mats of juniper and deciduous bushes; birch zones; heather patches;

OTTERS apparently range throughout the region. Fishbones discarded on the rocky shores are signs of their presence.

Dr. Errington, a zoologist with the Agricultural Experiment Station at Iowa State University, has been a visiting professor at the Swedish universities of Uppsala and Lund.

mossy growths; lichen-covered rocks. Where nothing could grow, the rocks and gravel lay exposed, but something adapted to the role usually grew wherever growth was possible—even in the most wave-beaten places.

In studying these islands I thought of the continuity of the pioneering thrusts and adjustments of all living things, of life insisting upon living as it could. The changes in vegetation, which became apparent as we moved deeper into this archipelago, were rather similar to those one could see while moving from low to high altitudes in mountainous regions. Close in along the coast (the equivalent in altitude to a region of lowlands or foothills), were all of the denser forest growths. Farther out (or up), came the birches and thickets and then the lesser tundra or alpine plants. Finally, far out (or far up), were nearly bare rocks.

Out in the archipelago, the rocks showed beneath the surface of the water as grayish, yellowish, or greenish blotches, which faded into the most indefinite outlines or sometimes into no real outlines at all. Our boat passed so close to some of these blotchy formations that I nervously wondered if our fisherman-pilot had seen them as he steered along the outskirts of island clusters, islets, and huge protruding or partly hidden boulders in a section of Swedish coastline into which very few people ever ventured.

As we poked along carefully, searching for a place to anchor, we could look down through the water at blue mussels and slimy rocks and sodden pieces of wood. Ashore in this rocky region one might, in some places, walk with ease from islet to islet if careful not to step in water that would slosh over the boot tops, and not to slip or to lose one's balance.

The rockier islands of fair size—from one to several acres in area—were mostly occupied by nesting colonies of different gull species. They sat on the island rocks unless we approached close enough to put them, protesting, into the air. Some of the islands had nests of eider duck as well as of gulls. Sometimes the eiders seemed satisfied with little more than token nesting

Mute swans, flying in formation over islands, breed in southern Scandinavia.

cover. At least, there they were, in patches of low vegetation, tucked in angles made by rock edges, the nests hardly even partially concealed. Perhaps the eiders were running out of choices for nest sites or perhaps they chose to nest near gulls for the protection against raiders that the noisy gull colonies might afford. In either event, many eiders nested on gull islands.

The most popular islands for nesting eiders, however, were those having thickets of juniper, carpets of heather, and arctic-alpine types of small plants irregularly covering the rocks. In the shallows about these islands or on the wet rocks around the edges, we could see eider droppings consisting of crushed mussel shells.

Eiders would not be everywhere, even in the archipelago belt so obviously suited to them, but on one island we found so many eiders that we decided to walk along the shore to avoid

Graceful Arctic tern defends single, speckled egg that lies on open ground.

Tawny owl shows serrated wing tips in low night flight across a hillside.

isturbing them unnecessarily. Despite ır care, incubating females kept ıshing from their nests. Then we ɔuld cover the exposed eggs with a ɡht layer of ground litter to make em less conspicuous to egg-eating rds. Four eider hens flushed from eir nests in one patch of heather ɔme ten feet in diameter as we cut ɛross a point on the way to our boat. ɔr variety, a shoveler hen, almost an ɛact counterpart of the shoveler hens ıat nest in the Dakotas, flushed from nest among those of the eiders.

All the flushed eider hens alighted on the water a couple of hundred ards away, where they sat until we ɛft. As the boat again headed deeper ıto the archipelago, we watched the iders gradually return to the island; rst a few, then they were all back.

A pair of sea eagles circled over ıe islands and the open sea. We saw three eagle nests in small trees: one was old and falling apart, with most of the nest on the ground. The islands in the vicinity of these eagle nests had no nesting colonies of gulls or eiders, but we did flush a black grouse from near the one recently maintained eagle nest that we visited. This was on an island on which were boggy spots, heather, and grassy growths—much the sort of terrain that a black grouse would be apt to choose on the mainland—and there the bird was, with miles of water between it and anything else resembling its habitat.

There were other mainland creatures in the archipelago, too: so far out that I wondered how they got there. Way out on the principal eider island on which our party landed, a viper was sunning itself on a flat rock. It tried to slip away as we approached. I wanted a picture and so headed it off, and the snake turned to strike

Eider duck, here floating in waters of Baltic Sea, abounds in region.

Full moon gleams over juniper clumps on an island far out in the archipelago where sparse vegetation replaces forest.

Draped between two limbs, a marten sleeps through part of the day. Animal is more arboreal during summer months.

at my boots as I blocked its movements in all directions and stood over it while making the photograph. My last view in the ground glass was of two and a half feet of glistening black snake disappearing into the heather.

The question of what a viper might be eating on this island. so distant from the mainland, was soon answered. We saw vole "sign"—burrows. paths, cuttings. and droppings — throughout the grass. heather, and low growths. The interest of other predators in the vole populations of these islands was further demonstrated by vole bones and fur in faded, wintertime owl pellets that lay on some of the rock surfaces. The pellets looked like those of short-eared owls, but they could have been those of the tawny or Ural owl or perhaps even the hawk owl or the snowy owl. The owls in question necessarily had to be among those that hunt where the cold winds blow and where some ground drifts over with snow while other ground stays bare: where the nights are long and daylight is restricted to a few hours of sun and to long dawns and twilights.

We traveled far into what is known as the outer archipelago of Norrtälje Skärgården, but never so far that we could not see still more islands and islets—clumps and strings of them like distant reefs—lying still farther ahead. The quiet sea and its emerging land became part of a hazed-over, dreamlike horizon. Something very old and fundamental seemed to characterize the setting. something older than the Baltic Sea itself or any one glacial or interglacial stage.

I searched in my mind, as I have often done in other parts of the world, to identify some feature with what James Norman Hall had referred to as the "spirit of the place." Perhaps it could be identified with the winds or the waves, with their capabilities for dominating violence. Or, it might be identified with the rocks coming out of the water or lying just beneath. Despite the calmness of the day and the visibility of the subsurface rocks, it was not hard to imagine being out on these waters when deadly turmoil might constitute the spirit.

Yet, more truly. some form of life should characterize this outer archipelago. Besides the eiders, gulls, and sea eagles, we saw velvet scoters. tufted ducks, mergansers and black guillemots. We saw razorbill auks that our hosts likened to stubby, flying cigars as they arose in front of the boat and swept past us. Flocks of hundreds of long-tailed ducks sat on the water, and the males called. As I think now of our spring day's visit, I can make only one nomination for the spirit of the place—the calling of the long-tails, one of the most wildly beautiful sounds in nature.

At times, these calls would come as a distant chorus, rising and falling, building up and letting down. Or the chorus might come from a large flock nearby, to build up and come over in a wavelike "ah-ah-oo-lee, ah-ah-oo-lee." The Swedes refer to this call of the long-tails as a spring song, or a hymn of the islands and of the sea. Whether one thinks of it as that, or as a breeding season ritual, it is its own essence of the wild and free.

The flocking long-tailed ducks do not even stay to breed in Norrtälje Skärgården. When their spring migration is over. their calling will no longer be the spirit of the archipelago. But, in the memory I carry with me, this will always be the sound of the islands and islets. of the gentle sunshine and long reaches of quiet water and indistinct horizons reaching north and east.

NEW WORLD

A court physician of sixteenth-century Spain first recorded

By Donald G. Humphrey

Natural history in the New World is often considered to have begun with the landing of Columbus and the invasion of Mexico by the conquistadors. Even the earliest letters of Cortes to his king, Charles V, include references to the curious plant and animal products of the new land. The true history of the flora and fauna, however, begins long before 1522, for the native inhabitants, who already were highly civilized, may be said to have begun researches in the natural history of the area. It is doubtful that any other early peoples took a greater interest in botanical and zoological matters. It is certain that at the time of the Spanish conquest none of the European nations was much superior to the Aztecs in knowledge of respective native biota. In one aspect, at least, the Aztecs were much more advanced, for they had established botanical and zoological gardens on an elaborate scale, far beyond any undertakings of a similar nature that had been attempted in the Old World at that period in history.

The close association of the zoological and botanical gardens was of practical significance as well as indicative of a strong interest in natural history. The Aztec people acquired an intimate knowledge of the medicinal properties and economic potential of the flora and fauna, and undoubtedly these gardens furnished plants and animals for the royal physicians. This practical use was complemented by a true aesthetic appreciation of plants for their beauty alone, a fact that illustrates further the degree to which civilization developed in pre-Columbian America.

Reports of various aspects of Aztec healing arts reached Philip II, son of Charles V, who became interested in both the medicinal and commercial value of the plants, animals, and minerals of the American colonies. Philip turned to Francisco Hernández, a royal physician, and assigned him to write the natural, ancient, and political history of New Spain, and to explore and map it.

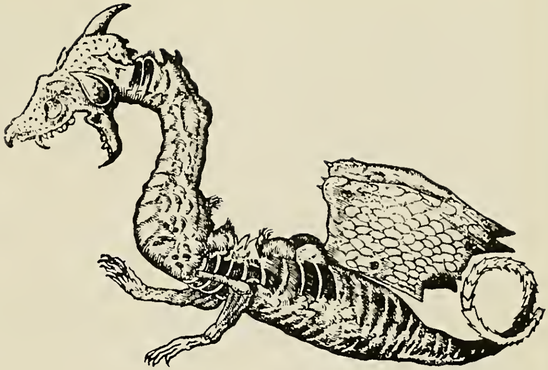
Hernández remains biographically rather little known. It is believed that he was born in Toledo, perhaps in the year 1514. He graduated as a medical doctor from the University of Salamanca, and later became a court physician in the Escorial, the royal palace.

In 1570, Hernández, with the new title of *Protomédico de Nueva España*, set sail for Mexico accompanied by his son and his assistant, the cosmographer Francisco Dominguez. For seven years Hernández traveled the conquered territory, interviewing the Aztecs, collecting plant, animal, and mineral specimens, viewing the uses made of the flora and fauna, learning their native names, reproducing them in paintings, testing their medicinal value, and recording the results of his various findings. That he was tireless in performing his duties can be seen in the obstacles he surmounted, for while Philip was generous in his support of the expedition, appropriating for it the considerable sum of 60,000 ducats, the King appears to have underestimated the magnitude of the task. Hernández was hampered by a lack of financial resources; only intense application enabled him to carry out his commission, in some instances with extreme privation. Five years had been allotted to him

Each book of the Reccho version
of Hernández' natural history volume

VIEWS

lants and animals of Mexico



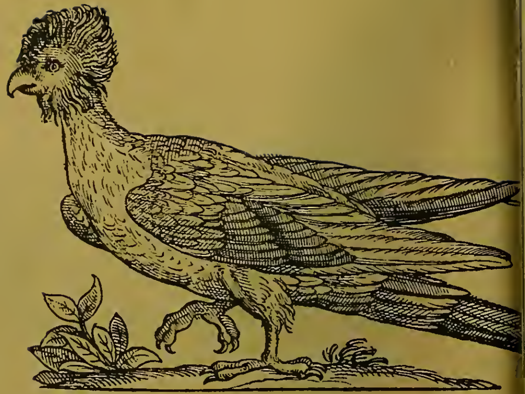
Dracunculus Monoceros and other dragons were discussed in some detail.

gins with this sketch showing vulture, orchid, manatee, and bison.

finish the task, but he remained for two more, engaged ontinually in his work and without time to practice his rofession, thus losing the opportunity of earning more ıan 20,000 pesos in medical salary for two years.

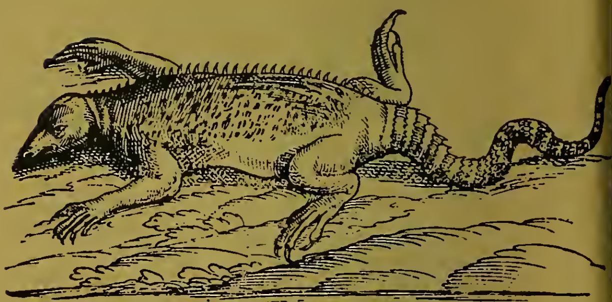
HERNANDEZ' enthusiastic observation and experimentation at times placed him in peril. Tales of the floral vonders of a country more than forty leagues beyond the reat city of Mexico encouraged him to make his long, ortuous journey to the west coast of this new land. It was here, in Michoacán, that he nearly perished from having eaten, in his zeal for experimentation, the latex of a shrub the Aztecs called Chupiri. This is *Euphorbia calyculata*, a strong purgative. He visited the famous gardens of Atzcapotzalco, Texcoco, and Huaxtepec, and the gardens and hospital at Huaxtepec particularly attracted his attention; much of his important work was done there. Taking advantage of his title of *Protomédico*, he was able to observe the hospitals and the Aztec physicians to gain a more complete knowledge of the materia medica of the land.

The result of this seven years' labor was a monumental study, beautifully illustrated by local artists, that com-

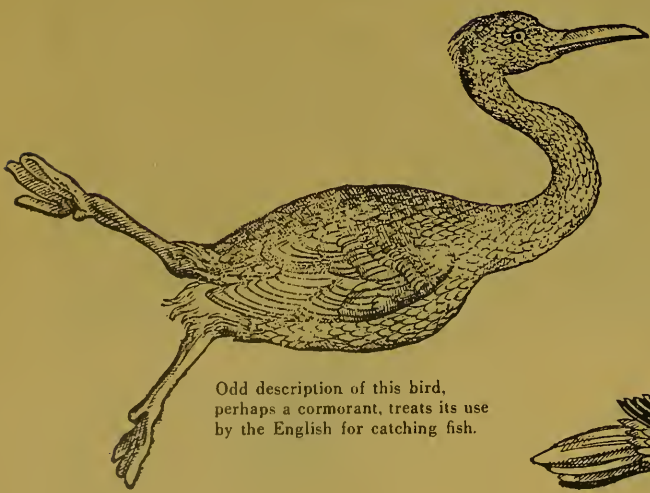


Vulture, still called *tzopilotl*, was also named *cozquaquauhtli*, which means "collared bird of prey."

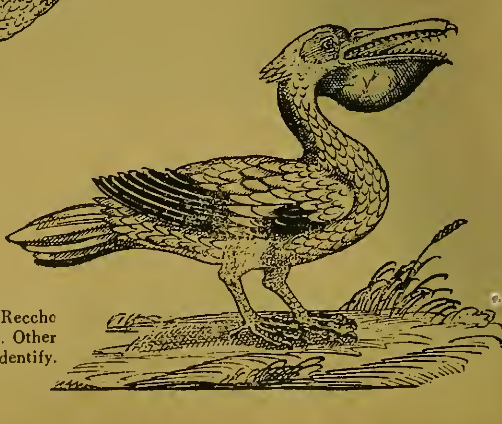
Handflower tree is one of best known Mexican plants. Its flowers were used as an anti-epileptic medicine.



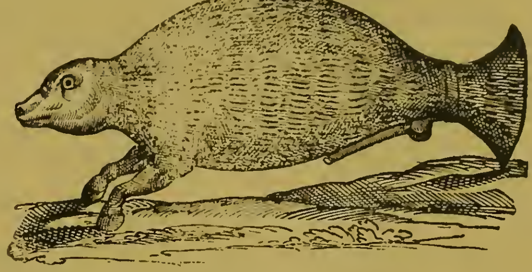
Although called *axolotl*, common name for salamander, this animal is probably a reptile, not amphibian.



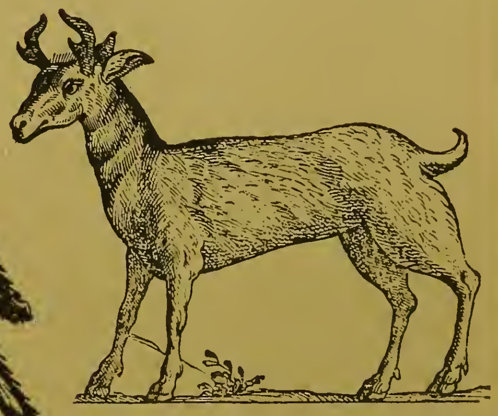
Odd description of this bird, perhaps a cormorant, treats its use by the English for catching fish.



Drawing of a white pelican in Reccho version is unmistakable. Other birds shown are harder to identify.



Manatee, or sea cow, a marine mammal, was depicted with hoofs more appropriate to terrestrial animal.



Hernández saw many big game animals in Aztec zoos. Animal shown here may be North American pronghorn.

Woodcut shows bird of paradise. Sketches in Reccho's work were redrawn from Aztec art in Hernández original.

Each book of the Reccho compendium, published between 1628 and 1651, ended with this picture of an orchid.

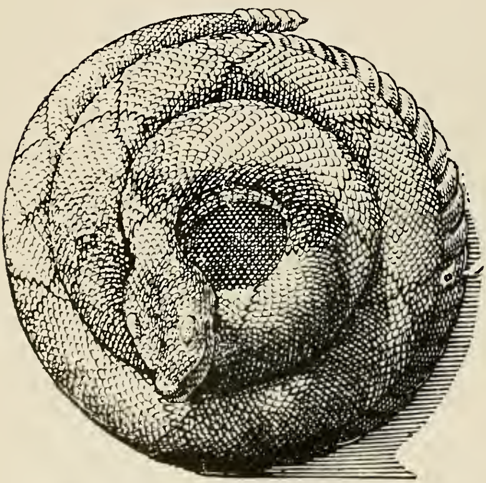
prised the first complete natural history of the New World. Hernández' work, a masterpiece of industry and erudition, was composed of sixteen volumes (six of text, ten of illustrations) that more than fulfilled his royal commission.

It would be pleasant to be able to report that this manuscript, which accompanied Hernández on his return to Spain in 1577, was published immediately by Philip, as Hernández had evidently believed it would, and that the original volumes were now available for study. Such is not the case. Both Hernández and his works were ill-fated.

In the fall of 1577, his mission accomplished, Hernández returned to Madrid, taking with him his manuscripts and illustrations, as well as a herbarium with live plants and many native seeds to adorn the royal gardens of Spain. The seven years of excessive and arduous travel, the worry and embarrassment about financial matters, and the coolness and sometimes open hostility shown the *Protomédico* by envious lesser officials in New Spain had undermined Hernández' health. The cost of assistants, artists, materials, travel, and the extra two years of work had exhausted his finances. His dreams of seeing his work published were soon to be shattered: instead of being sent to the printer, the manuscripts were buried in the library of the Escorial, although "with every honor," as the Mexican scholar Nicolas León wrote, for they "were beautifully bound, in blue leather covered and worked with gold, with clasps, corners and ornaments of silver, all very heavy and of excellent workmanship and design." The handsomely colored illustrations, drawn by Aztec artists, were placed on exhibit and also adorned the private apartment of Philip II.

Dejected by the failure of the King to publish his writings, wearied, and in ill-health from his long and arduous labors in the New World, Hernández died in January of 1587, deprived of the satisfaction of seeing his monumental natural history in print. Today he lies in an unmarked grave, forgotten by his countrymen.

Three or four copies of his natural history were left in New Spain for use there. Of these manuscripts nothing is



Rattlesnake, found only in New World, was written of by Hernández, who described how hollow fangs inject venom.

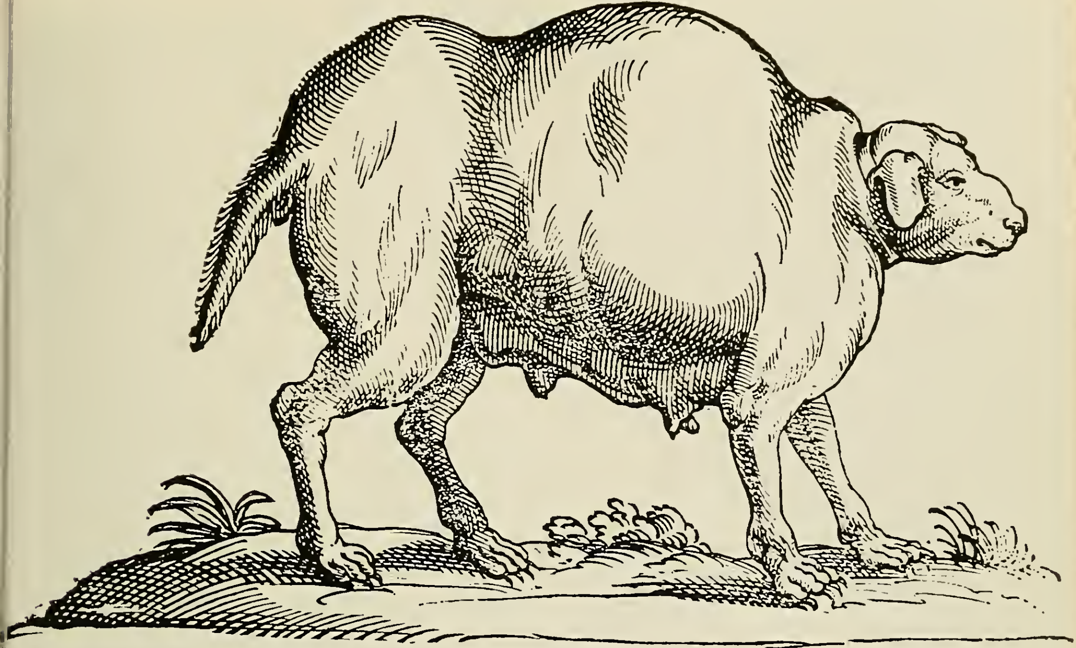
Dr. Humphrey, whose article about Francisco Hernández' first natural history of the New World is an outgrowth of a long interest in the history of science, is Chairman of Oregon State University's Department of General Science.

known; it is probable that all were lost within a few years of their preparation. As for the volumes in Spain, the great fire of June 7 and 8, 1671, consumed the Royal Monastery of the Escorial and destroyed the works of Hernández. Thus, the world lost the complete, original works of the first comprehensive natural history of the New World.

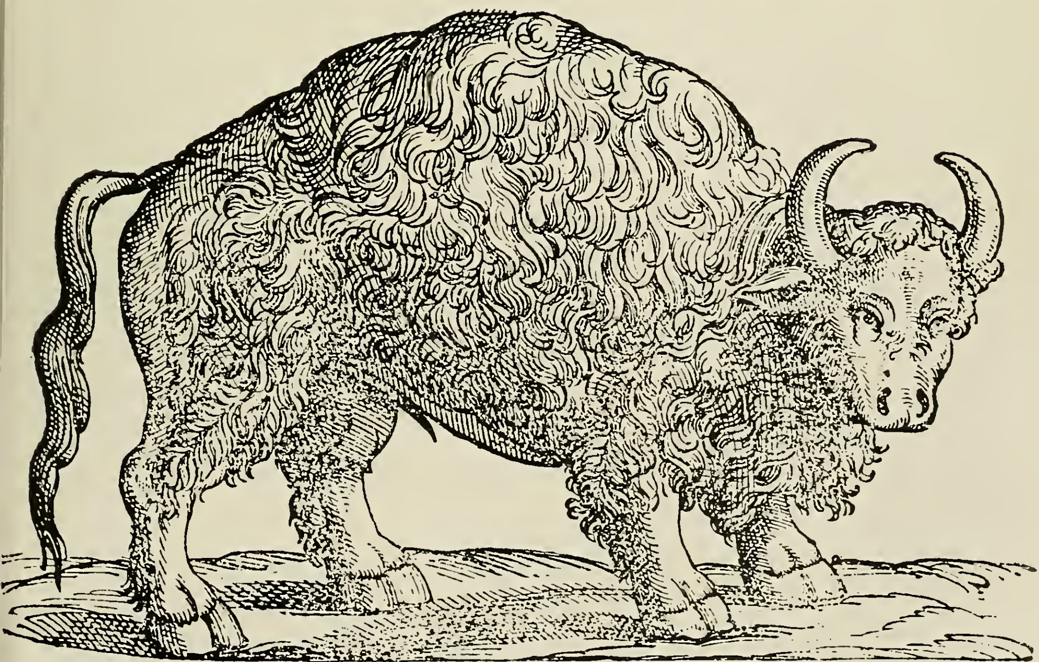
Shortly after the death of Hernández, the King appointed another of his court physicians, Dr. Antonio Reccho, an Italian, to make a compendium of the medically valuable part of the Hernández manuscript. Reccho's competence has been questioned; nevertheless, without his labor it is doubtful that any part of Hernández' work would ever have seen print. However, Reccho's compendium, completed in 1589, met with no better immediate fate than the original, for it, too, remained unpublished and was taken to Naples by its compiler. This Reccho compendium was used by Juan de Barrios in a short treatise published in 1607, and also served as the basis for a book by Francisco Ximenez, published in Mexico in 1615 under the title *Cuatro Libros de la Naturaleza y Virtudes Medicinales de las Plantas y Animales de la Nueva España.* Neither of these books was illustrated. After Reccho's death, his work was sold by his nephew to Prince Frederico Cesi, duke of Aqua Sparta, a devoted student of natural history and founder, in 1603, of the *Accademia dei Lincei*—the Society of Lynxes—which counted Galileo among its earliest members.

Prince Cesi did not stint in preparing the Reccho compendium for publication. With other learned members of the Society of Lynxes, he had illustrations in perspective made from the original Hernández material and arranged and annotated the text. In rendering the Hernández illustrations, Prince Cesi's artists did not reproduce the color, nor did they include the Aztec symbols that indicated the habitat of the plants and animals. They worked with great skill, however, and it is to them that we are indebted for some of the first illustrations of American plants and animals. Although the Society of Lynxes completed its work on the Reccho compendium by 1628, the exact date of the *Editio Princeps* is in doubt. Dates cited range from 1628 to 1651. The illustrations that appear with this article are taken from the beautiful 1651 edition.

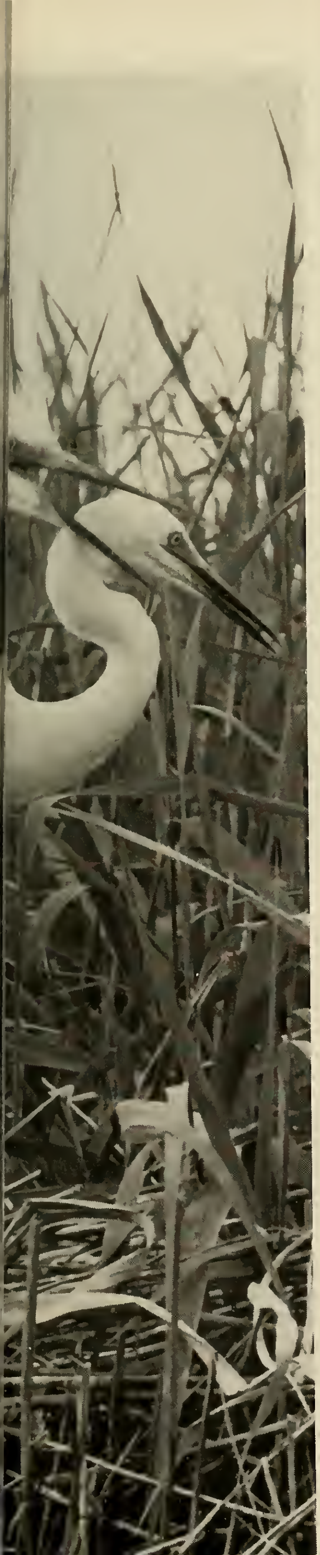
The complete work as it appears in the 1651 edition is in two volumes, bound together, with each volume divided into several books. Only the first volume is related directly to the work of Hernández. The second one is devoted to commentaries and contributions of the various scholars of the society. Included in the first volume are descriptions of some 400 plants, along with 350 engravings. An appendix to this section includes about 300 drawings of native plants with but scant descriptive material. Hernández describes or refers to more than 1,200 native plants. The ninth book describes some 25 animals, and the tenth treats the minerals of the land. This work is of great historic interest, not only because it is the first extensive publication dealing with the natural history of the New World, but also because of the scholarly work done by Hernández. Even in the light of more recent studies this singular achievement still retains its position as a work of high fidelity and authority.

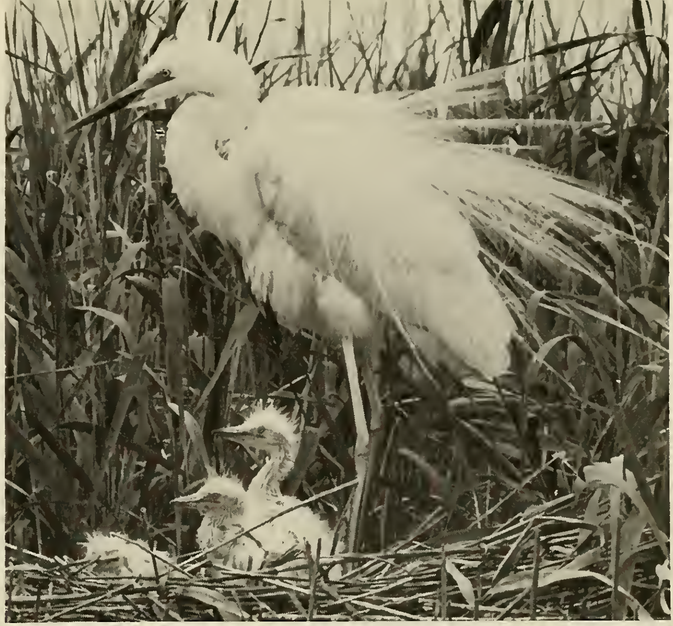


Native dog is presented as an ungainly creature of bizarre proportions. The Aztec artists who illustrated the Hernández manuscript worked in color. Revised for Reccho's volume, the drawings appeared in black and white.



Hernández' depiction of the bison, which he called *Taurus Mexicanus*, was one of the first pictures published of this animal. Bison is discussed in great detail in Reccho compendium by a member of the Society of Lynxes.





GREAT WHITE HERON, one of Europe's rarest birds, stands with mate at nest.

PLUMES were once so fashionable that collectors nearly exterminated species.

A Bird Search in Hungary

Despite pressures, most species flourish

By GUY MOUNTFORT Photographs by ERIC HOSKING

IN PREWAR DAYS, Hungary was a mecca for ornithologists, and the fame of the rare birds inhabiting the great Hortobagy Plain and the Lake Balaton regions was world-wide. Today, like so much of the rest of Europe, Hungary has undergone a rapid transformation. Huge areas, which were unspoiled wilderness a few years ago, have succumbed to the tractor and bulldozer. The Hortobagy, where picturesquely dressed "cowboys" formerly herded thousands of horses across the vast prairie, has been taken over by collective farms. The once numerous troops of great bustards—Europe's largest game birds — that strutted over the prairie are steadily diminishing in numbers. They still breed in the huge cornfields, but few of their nests escape the blades of the mechanical reapers. Lake Balaton itself, one of the most beautiful lakes of Central Europe, is now ringed with holiday camps and hotels.

Sad though these inevitable developments are to naturalists, the situation for rare birds in Hungary is nevertheless no more alarming than in many other lands where the pressure of human population has increased. The Hungarian government's record in matters of conservation is a good one. Several strictly protected sanctuaries have been established, and at least some species of rare birds have been able to maintain their numbers in spite of the country's rapid industrializa-

tion and intensive collective farming during the postwar years.

In order to obtain an up-to-date assessment of the status of Hungary's rare birds, a group of six British ornithologists was given permission by the Hungarian government to explore the country in May and June of 1961. The Hungarian Institute of Ornithology and the Natural History Museum in Budapest provided willing co-operation. Visits were made to all the centers of interest in the plains, forests, marshes, and mountains. Several thousand valuable photographs and many sound-recordings were obtained. Probably the most important discovery was that Hungary's great white heron, one of Europe's rarest and most spectacular birds, had actually increased in numbers. This species is related to the American great white heron, which occurs in the state of Florida and in the Caribbean area.

PHOTOGRAPHING the small Hungarian population of great white herons proved to be unexpectedly difficult, as they are excessively shy, unlike other heron species. Although their chief remaining breeding grounds are in the Caspian Delta of the Volga and the Black Sea Delta of the Danube, small colonies have survived in Austria, Hungary, and Macedonia. At the turn of the century, they came close to total extermination and the birds are still on the danger list, although they are no longer slaughtered for their beautiful "aigrette" plumes. While on winter migration, many still fall to the trigger-happy sportsmen of the Mediterranean countries.

There were spoonbill colonies nesting at Lake Velence and in the Kisbalaton sanctuary. Only a hundred miles separates these two areas, yet all the birds at Lake Velence were incubating eggs at a time when the Kisbalaton colony had young already learning to fly. Each time a parent arrived with food there was indescribable commotion as all the young birds rushed forward, begging shrilly to be fed. The adult was chased round and round the lagoon until its rightful young fought their way to its side and forced it to regurgitate the food. This was done by seizing the parent's bill and tugging it downward, and then thrusting its spatula-shaped bill into the parental gullet.

As PURPLE HERON extends neck, *left*, two nestlings seem to imitate action.

Male little egret, with wings spread, presents mate with stick for the nest. Like American snowy egret, this bird has black legs and bright yellow feet.

The large birds of prey in Hungary appear not to have diminished in numbers to any greater degree than in most western countries. Both imperial and lesser spotted eagles were still found nesting in some regions. An exception is the white-tailed eagle, which has the distinction of being Europe's largest bird of prey (apart from the carrion-eating vultures). Apparently no more than three or four pairs of these majestic birds remain in Hungary, and the only known area where they still nest is in the southern valley of the Danube near the Yugoslavian frontier.

An exciting incident was witnessed one day in the Vertes Mountains, when the nest of an imperial eagle was being examined. A pair of saker falcons, which had a nest nearby, suddenly attacked the flying eagles, diving on them repeatedly at tremendous speed. The much larger eagles dodged this way and that, rolling over on their backs and snatching at the falcons with their huge yellow talons, but the fierce little falcons won the field.

A major problem to Hungarian conservationists is the egg-collecting that is carried on, chiefly by well-educated people who sell clutches to collectors in other countries. As an example, news reached the British expedition that some rose-colored starlings, a species that had not nested in Hungary for twenty-five years, had just been discovered breeding in the valley of the Tisza River. These striking pink-and-black birds are of Asiatic origin. They are wanderers and nest in eastern Europe only at rare intervals. After an arduous journey of 250 miles, the expedition members located the spot where the birds had been seen, only to discover that every one of the seventeen nests had already been robbed by energetic collectors!

A remarkable variety of interesting birds was discovered in the Kisbalaton marshes. Apart from the great white herons and spoonbills, there were

Black "mustache" is field mark of male bearded tit, here covering nest.

Cormorant droppings kill trees, thus depleting nesting sites for other birds.

Squacco heron is peach-colored and has a vivid blue, green, and black bill.

thriving colonies of gray herons, purple herons, little egrets, night herons, and squacco herons. The three last-mentioned species were found nesting side by side in bushes. Most of the trees in the marsh had already been killed by the excreta dropped by nesting cormorants, which have greatly increased since the war; measures to cut down their population are now planned in order to enable the rarer species to find sufficient nest sites.

Lake Velence, which is almost two hours' drive from Budapest, was noteworthy for the many species of smaller birds that nested in its extensive reed-beds, and for the hosts of ducks and waders in its adjacent marshes. The tame little bitterns were the favorites with the photographers. At one nest, a photographer missed

Older spoonbills in a nesting colony are distinguished from young by crests.

Little bittern appears unconcerned at close approach of the photographer.

his footing while stepping from the boat to the blind, and fell in the lake with a big splash. A little bittern, sitting on her nest only six feet away, merely stretched up her long neck and regarded the commotion with unwinking yellow eyes before settling back on her eggs. The colorful little crakes, which are no larger than starlings, were equally tame and permitted themselves to be examined on their nests at a distance of only three feet. The blue-headed males did most of the incubating, but were difficult to photograph because of the rapidity with which they pulled dead vegetation over their nests and themselves when they settled on the eggs. They have remarkable "songs" — a descending scale of explosive, quacking notes, which die away in a rapid chuckle.

Among the smallest occupants of

Female little crake is difficult to photograph at nest, despite abundance of them at Lake Velence, as eggs are incubated almost exclusively by male.

Young eagle owl, Europe's largest, snaps at intruders from its cave nest in Matra Mountains, where its parents have deposited a mole and a hedgehog.

Mr. Mountfort is secretary of the British Ornithologists' Union; **Mr. Hosking** is England's foremost bird photographer. Their trip to Hungary, documented here, was made in 1961.

the reed-beds, the bearded tits were the most plentiful. The males, distinguished by black "mustaches," are remarkably acrobatic on the wing, and are certainly the most entertaining to observe of all the twelve species of European tits. It was while photographing the nest of a bearded tit that the expedition narrowly missed disaster. A sectional metal pylon had been erected in the bed of the lake to enable a blind to be raised above the level of the water at the edge of the reeds. The photographer had just emerged after several hours in the blind, when a violent storm broke. The boat containing him and other members of the party had gone barely fifty feet away when, with a blinding flash, the pylon was struck by lightning.

While it was working in Hungary's heavily wooded mountain ranges, the expedition was able to see eight of the nine species of Europe's woodpeckers. The most numerous was the Syrian woodpecker, which was common even in the vineyards and city parks. Two nests of Europe's largest owl, the eagle owl, were found after the party climbed some rocky cliffs. This bird somewhat resembles the American great horned owl and is capable of killing deer fawns or foxes, though it preys chiefly on rodents. Photographs were taken of one of this species' fierce nestlings, snapping its bill viciously at the intruders.

There was no shortage of brightly colored birds. Golden orioles, in brilliant yellow and black, were singing everywhere. Colonies of exotic bee-eaters were nesting in many sandy cuttings. Boldly colored hoopoes, with their high, fan-shaped crests, were feeding young in hollow trees in every wood. Handsome blue-and-chestnut rollers could be seen perched on telegraph wires along the main highways. In spite of having neither seacoasts nor high mountains, Hungary can boast of an exceptionally rich and varied population of wild birds, and the country remains a wonderland for naturalists.

Marsh grass at Lake Velence hides simple nest of the black-tailed godwit.

Geology's Time Clock

ŀadioactive minerals and fossils both ıid in decipherment of earth history

By Norman D. Newell

Scarcely two hundred years ago, before geology became a systematic study, it was generally believed that the earth was unchanging and its mountains, valleys, seas, and rivers were viewed as the products of original creation. Although such an idea did not harmonize with men's frequent discoveries of fossil sea shells and the bones of strange animals among the rocks in mines or on mountain ridges, the concept was rarely challenged. Today, of course, we interpret the fossil record as documentary evidence of evolutionary changes among living creatures, and we realize that the rocks of the earth's crust tell a story of dynamic changes in climate and in the distribution of land and sea. We also know that comparable changes in the landscape are even now taking place throughout the world but that, generally, these changes are so slow by human standards as to escape notice.

The reason for this contrast in view between our eighteenth-century ancestors and ourselves revolves largely about the development of methods for dating geological events. This capacity to analyze occurrences that took place millions of years ago is one of the triumphs of modern geology, and one that had to be achieved before a history of the earth could be written. By means of these dating methods, a standard scale of geologic time has been developed that provides the basis for deciphering in some detail geological and evolutionary events of the past one-half billion years. Further, the same methods furnish us with scattered dates that reach back nearly to the beginning of the earth—some 4.5 billion years ago.

The layers of sedimentary rock that make up the many strata of the earth's crust, laid down gradually as deposits of mud and sand during many millions of years, may be imagined as a great book—its subject, earth history—lying face downward, with its earliest pages the bottom ones. Thus, geological history could scarcely have been written until the individual strata, or pages, were accurately identified at scattered localities and then dated in chronological order. One major advance in the reading of this record took place in 1799 when William "Strata" Smith, the English surveyor, demonstrated

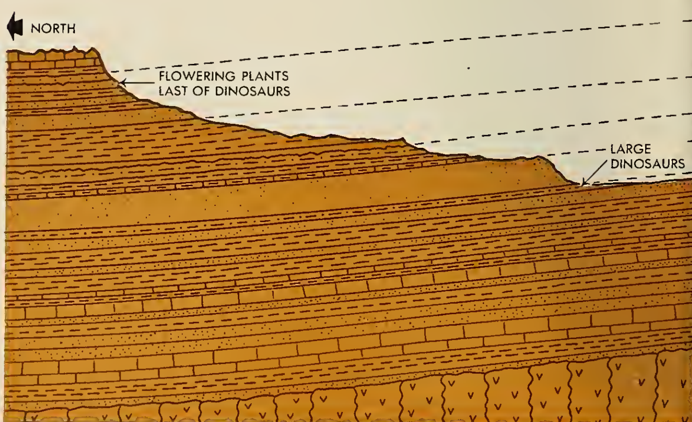
Grand Canyon's rock layers, nearly one mile in thickness, contain fossil records of successive geological ages.

SMITH'S drawings, *above*, supported his ideas on sequence of fossil forms.

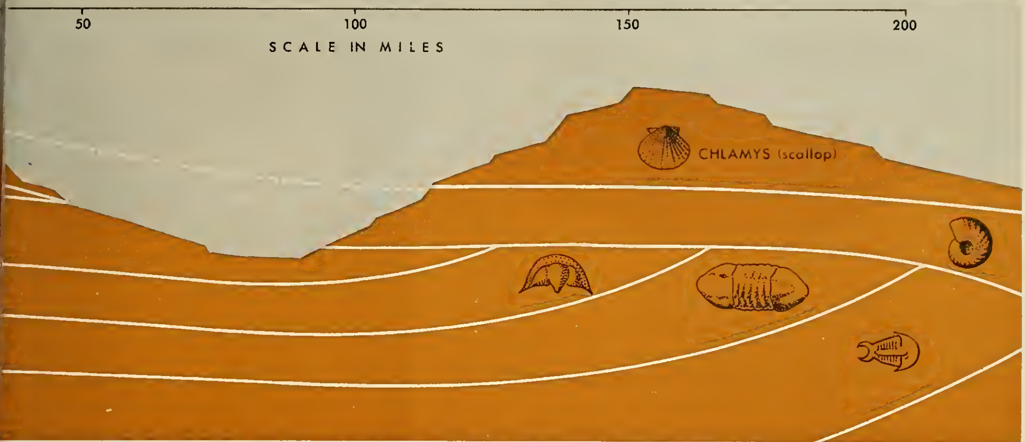
TYPICAL INVERTEBRATE FOSSILS from sequence of strata at two sites some 200 miles apart form basis for determining

that successive sedimentary layers of the earth's crust contained fossilized animals and plants of kinds that allowed identification of the particular strata in which they were found. The sequence of these fossil faunas and floras, in turn, provided chronological indication of the geological ages in which the fossils had lived. As Smith put it in a paper published in 1816: "The organized Fossils (which might be called the antiquities of Nature), and their localities also, may be understood by all, even the most illiterate: for they are so fixed in the earth as not to be mistaken or misplaced; and may be as readily referred to in any part of the course of the Stratum which contains them, as in the cabinets of the curious: and, consequently, they furnish the best of all clues to a knowledge of the Soil and Substrata."

THE nomenclature of the geological time scale has gradually developed over a period of many years, and the names chosen for the major divisions are neither uniform nor consistent. For example, very early the rocks of the earth's crust were classified, from older to younger, into Primary, Secondary, Tertiary, and Quaternary, and the last two names are still in general use for geologic sys-



VERTICAL SECTION of Grand Canyon and the cliffs to its north show various sedimentary units. At extreme bottom

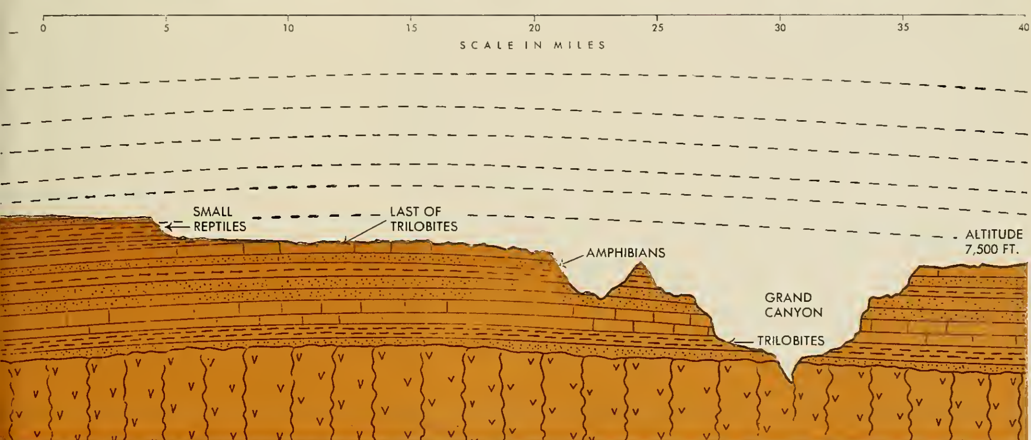


their relative geologic ages. Only one specimen from the groups of fossils from each stratum has been illustrated.

tems. In other cases, the systems and their equivalent periods were named for regions in Europe and elsewhere. For example, the Cambrian, Ordovician, and Silurian systems were first worked out in the nineteenth century and named in Wales, after the Roman name for that country (Cambria), and the names of ancient Celtic tribes that formerly lived there (Ordovices and Silures). The Pennsylvanian system (or subsystem) was named for the state of Pennsylvania, where rocks of this age are well displayed; Mississippian, for the Mississippi Valley; and Permian, for the province of Perm, in Russia. The Jurassic system was named for the Jura Mountains, along the border between France and Switzerland. Other systems, in turn, were named for outstanding physical characteristics; for example, Carboniferous (for coal-bearing), Cretaceous (for chalk-bearing), Triassic (for its threefold character), and the like. Subdivisions of the various systems, in turn, are known as series (their equivalent duration in time are called epochs) and are further divided into stages (equivalent time duration, ages).

For the most part, the series and stages are named for geographical localities, but many carry names that indicate the general level of evolution of characteristic fossils (for example, Eocene, "dawn of the recent"). Finally, the systems themselves were grouped in three larger time divisions that are known as eras. These three are the Paleozoic (for "ancient life"), the Mesozoic (for "middle life"), and the Cenozoic (for "modern life").

The strata that represent these three eras are underlain by the oldest rocks, the Precambrian, which contain few, if any, remains of animals and only a few low forms of plants. Consequently, Precambrian rocks are not readily classified in world-wide systems and series. The subsequent, and abundantly fossiliferous, systems are some-



lie Precambrian rocks. Broken lines at top indicate the extent of the beds as they appeared before canyon was cut.

HALF OF ORIGINAL ELEMENT DECAYS TO	RADIOGENIC ISOTOPE	IN YEARS
Uranium 238	Lead 206	4,500 million
Uranium 235	Lead 207	710 million
Thorium 232	Lead 208	14,000 million
Rubidium 87	Strontium 87	4,700 million
Potassium 40	Argon 40	1,300 million
Carbon 14	Nitrogen 14	5,600 million

times grouped in the Phanerozoic (for "evident life") eon of geologic time.

This paleontological method of dating rocks has resulted in a universally adopted scale of relative chronology that provides the basis for classifying and mapping fossiliferous rocks according to their age relationships. Geological events in the history of a region, such as times of igneous activity, glaciation, mountain building, and the like, are dated by means of fossils that were living at the time these events occurred, and the fossils, themselves, furnish a surprisingly detailed history of life. It must be recognized, however, that the fossil record does not indicate the absolute age of rocks, but can show only that a particular fossil assemblage is older or younger than, or the same age as, other groups of fossils. Only recently methods for measuring absolute age in years have become available.

In the early days of modern science, during the seventeenth and eighteenth centuries, Christendom held the opinion that the age of the earth was about 6,000 years—an opinion based on a literal interpretation of biblical genealogies. Shakespeare's *As You Like It* (1599), for example, contains the statement: "The poor world is about 6,000 years old. . . ." Indeed, in 1654, Archbishop Ussher proclaimed that creation had occurred precisely in 4004 B.C., and this date found wide popular acceptance until the end of the nineteenth century.

In 1899, however, the Irish geologist Joly undertook the calculation of the ocean's absolute age along lines suggested earlier by Edmund Halley, the British astronomer royal. Halley had argued that the salinity of the ocean is a result of the accumulation of dissolved salts carried to it by the earth's rivers and streams. Assuming that the original ocean had been fresh, Joly divided the sea's estimated total sodium by the estimated annual increment that was delivered by streams. In this way, he obtained a figure of approximately 100 million years. The simplicity of this calculation was attractive, and most geologists felt that Joly's figure at least provided a reliable minimum age for the earth, even though it was realized that his estimate was probably much too low, as the present rate of land erosion and transportation of sodium to the sea undoubtedly was higher than in the past.

It was not until the twentieth century that modern geochronology was born, based on Henri Becquerel's discovery in 1896 of radioactivity in uranium. In 1907 a Yale Professor of Physics, Bertram Boltwood, showed how to make use of radioactive isotopes to date rocks of the earth's crust. These isotopes are elemental substances that are found not only in many natural minerals, but also in the carbon-bearing structures of such organic materials as wood and molluscan shells. Radioactive isotopes break down, or "decay," at uniform rates and become transformed into stable, non-radioactive isotopes in the process. Since the specific rate of decay, or "half-life," is quite accurately known, precise measurement of the ratio between radioactive and stable isotopes in a mineral or organic sample permits calculation of the sample's age in years according to the equation:

$$\text{age} = \frac{1}{\text{decay constant}} \times \log\left(\frac{\text{wt. radiogenic isotope}}{\text{wt. radioactive isotope}} - 1\right).$$

The decay constant, or half-life, of a radioactive isotope is the length of time required for the disintegration of one-half of any amount of the isotope. This can be stated in a different way. A radioactive element (A) decays at a known rate into a second element (B). If all of the B came from A, the ratio of B to A indicates how long ago the rock containing the element was formed. Uranium 238 is a radioactive element found combined with oxygen in the mineral uraninite. (The number 238 refers to the element's mass number.) It decays into lead (Pb_{206}) by a series of radioactive changes. The half-life for U_{238} has been established as 4,500 million years, irrespective of temperature, chemical conditions, or pressure. In other words, in 4,500 million years, a single gram of U_{238} would be reduced to one-half gram, and 4,500 million years later one-fourth of the original gram would be left. Hence, precise analysis of the lead-uranium ratio reveals the age of uraninite-bearing rocks. Other radioactive elements currently used in dating studies are found in the half-life chart on page 36.

The decay constants for many radioactive isotopes are currently known to within 5 per cent error (in some cases that error is probably smaller than 2 per cent). Other sources of error lie in the chemical analysis itself, in the degree to which the sample has been altered chemically since it was formed, and, finally, in the determination of the stratigraphic position or the paleontological age of the sample. Even so, constant refinement of techniques of isotope dating has resulted in steady increases in estimates of the earth's age. Indeed, from Joly's 100 million figure, the apparent age of the earth has, in recent years, increased at a rate of approximately one billion years per decade. But there are good reasons to believe that this figure will finally be established at something less than five billion years. For example, isotopic dates of a number of meteorites indicate an age near 4.5 billion years for these celestial objects, and

In addition to being Chairman and Curator of The American Museum's Department of Fossil Invertebrates, Dr. Newell is also a Professor of Geology with Columbia University.

most astronomers believe that all meteorites originated contemporaneously with the solar system and the earth.

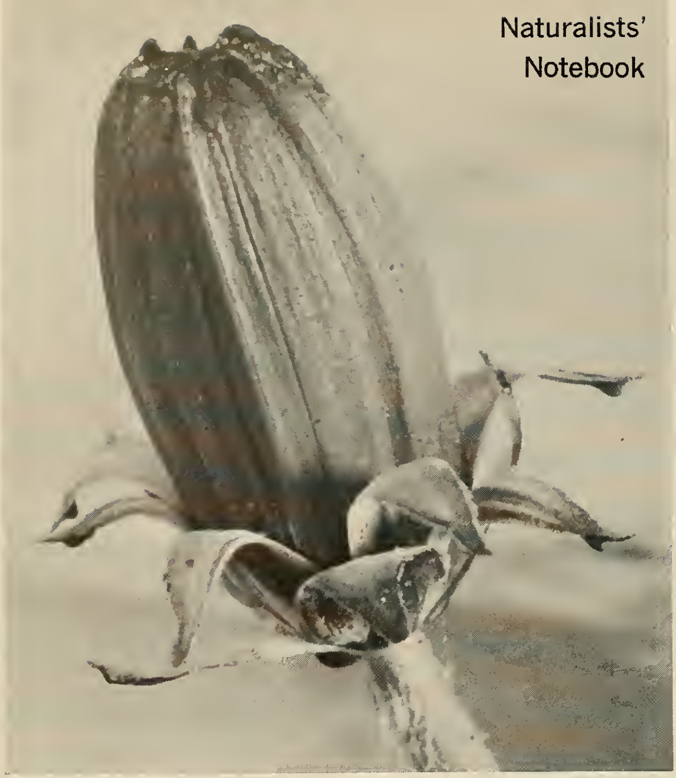
The oldest isotopic date thus far established for terrestrial rocks is 3.4 billion years, a measure obtained from igneous pegmatites intruded into older sedimentary rocks (thus marking the sediments as the more ancient formation) found in Rhodesia and in the Murmansk region of Russia. The somewhat younger Bulawayan series of Rhodesia consists of metamorphosed sedimentary rocks containing calcareous deposits — cryptozoon — that are generally attributed to low forms of algae. These rocks, too, are intruded by, and hence are older than, igneous rocks that are dated at about 2.6 billion years. Both the character of the Bulawayan rocks and the fossil evidence of plant life that they contain suggest that the surface temperatures and atmosphere of the earth at that remote date were not greatly different from what they are today.

To trace the earliest records of life farther forward, it is possible to turn to the unequivocal remains of unicellular plants that have been found in the rocks of the Gunflint formation, north of Lake Superior. These rocks are radio-dated to about 1.7 billion years. However, undoubted remains or traces of animals are strangely lacking in rocks older than about 600 million years. By then, some 86 per cent of geologic time lies in the past.

Our knowledge of the earth has increased immeasurably since the eighteenth century, when it was thought that the whole history of the cosmos could be crowded into 6,000 years. Paleontology has provided a panoramic view of the evolution of life, and this furnishes us with a geologic time scale for dating and correlating in considerable detail events of later earth history. But this time scale has been only relative, without fixed points. Absolute dates are now being supplied with increasing frequency and accuracy by studies of radioactive minerals. Isotope analyses are gradually supplementing and reinforcing the paleontological method for dating events in earth history. The use of radioactive isotopes for this purpose has proved conclusively that earth and the solar system are of great antiquity, and prospects are good that a definite date may ultimately be given to the origin not only of the earth, but the entire solar system, as well.

GEOLOGIC TIME SCALE

ERA	SYSTEM AND PERIOD	SERIES AND EPOCH	SOME DISTINCTIVE FEATURES	YEARS BEFORE PRESENT
CENOZOIC	QUATERNARY	RECENT	Modern man	11 thousand
		PLEISTOCENE	Early man; northern glaciation	½ to 2 million
	TERTIARY	PLIOCENE	Large carnivores	13 $\pm$1 million
		MIOCENE	First abundant grazing mammals	25 $\pm$1 million
		OLIGOCENE	Large running mammals	36 $\pm$2 million
		EOCENE	Many modern types of mammals	58 $\pm$2 million
		PALEOCENE	First placental mammals	63 $\pm$2 million
MESOZOIC	CRETACEOUS		First flowering plants; climax of dinosaurs and ammonites, followed by extinction	135 $\pm$5 million
	JURASSIC		First birds, first mammals; dinosaurs and ammonites abundant	181 $\pm$5 million
	TRIASSIC		First dinosaurs. Abundant cycads and conifers	230 $\pm$10 million
PALEOZOIC	PERMIAN		Extinction of many kinds of marine animals, including trilobites. Southern glaciation	280 $\pm$10 million
	CARBONIFEROUS	PENNSYLVANIAN	Great coal forests, conifers. First reptiles	310 $\pm$10 million
		MISSISSIPPIAN	Sharks and amphibians abundant. Large and numerous scale trees and seed ferns	345 $\pm$10 million
	DEVONIAN		First amphibians and ammonites; fishes abundant	405 $\pm$10 million
	SILURIAN		First terrestrial plants and animals	425 $\pm$10 million
	ORDOVICIAN		First fishes; invertebrates dominant	500 $\pm$10 million
	CAMBRIAN		First abundant record of marine life; trilobites dominant	600 $\pm$50 million
	PRECAMBRIAN		Fossils extremely rare, consisting of primitive aquatic plants. Evidence of glaciation. Oldest dated algae, over 2600 million years; oldest dated meteorites 4500 million years	



Dandelion inflorescence, *above*, has many whole flowers within it. Bracts, not petals, are at flower head's base.

Striking pattern of tiny individual florets surrounded by pappus hairs is seen in a cross section of flower head.

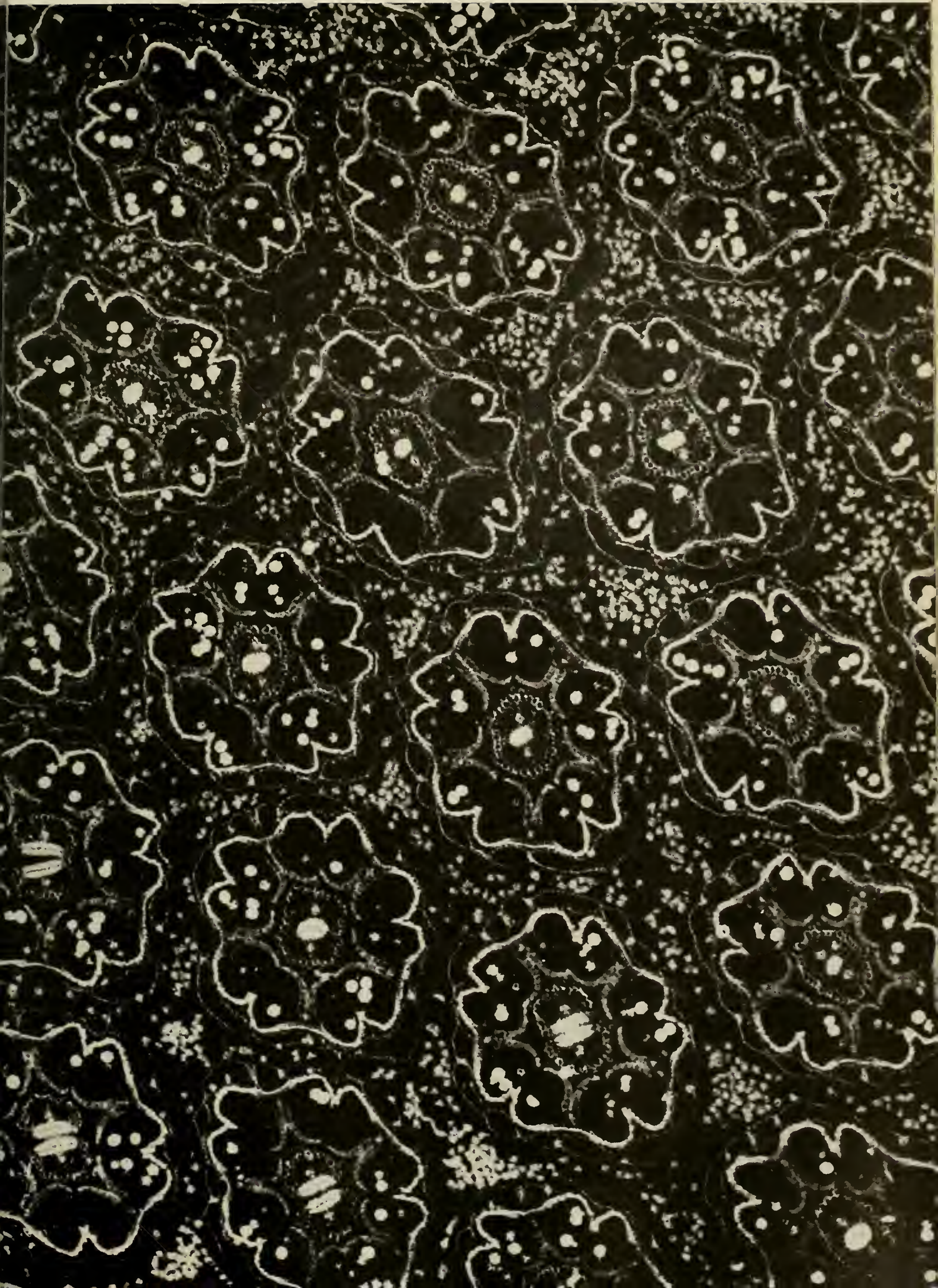
HIDDEN WORLD OF PLANTS

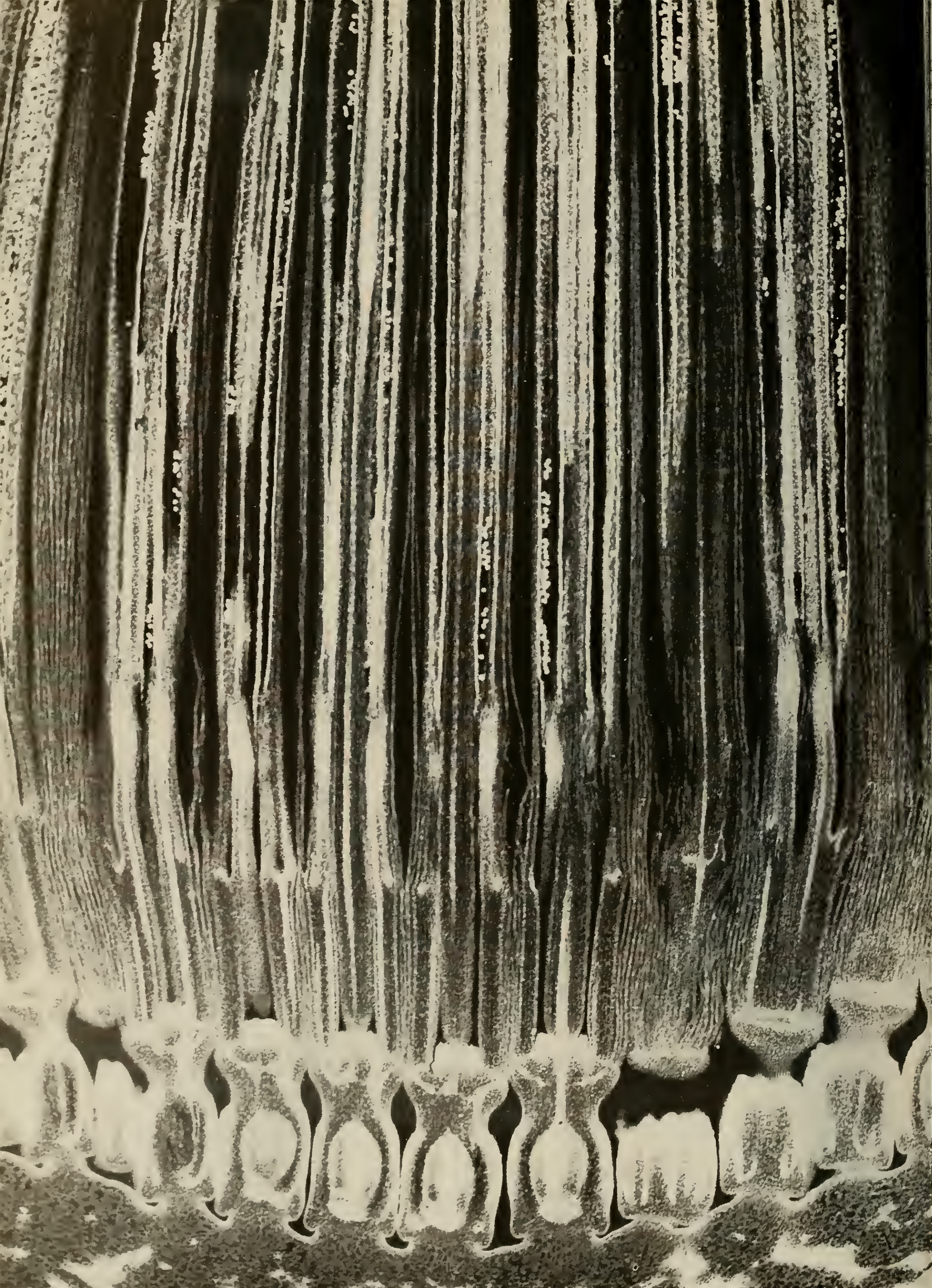
Even simple flowers show complex beauty

Many of the world's most familiar flowers can be found in the enormous Compositae family. There are the asters and daisies, the goldenrods and thistles. They are distinguished by the compound flower heads, which take a great variety of forms. Some, such as daisies, have a central disk of tiny tubular florets entirely surrounded by rays. Others are rayless, while some — including the dandelion—bear strap-shaped florets.

It is the dandelion, beloved by children and anathema to gardeners, whose intricate structure—from young flower head, or inflorescence, to seed-bearing pappus—is so dramatically exposed on these pages.

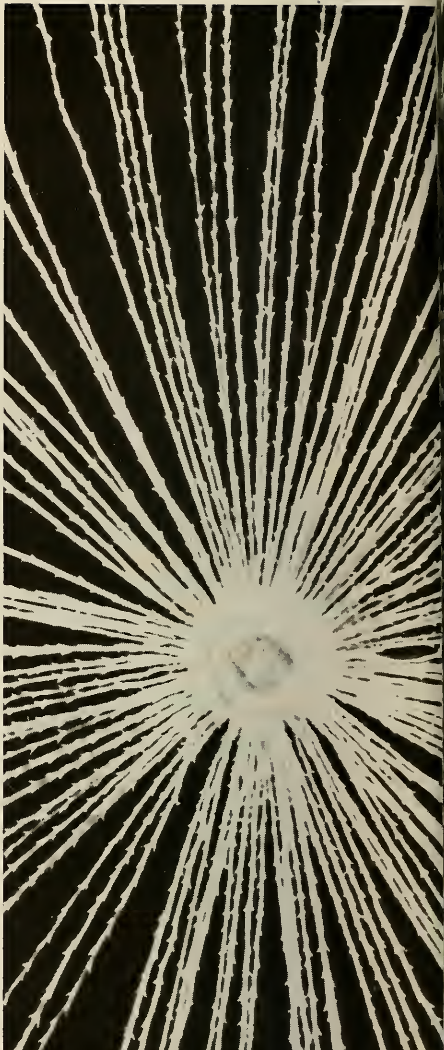
The photomicrographs were made by Dr. C. Postma, a practicing physician in Bussum, Holland, whose book, *Plant Marvels in Miniature*, was recently published in this country by The John Day Company. Each picture took some two months to complete. The result is an astonishing record of the miracle of plant composition, and fulfills Dr. Postma's hope that those who see his pictures "will look with a fresh eye at the plants around them."

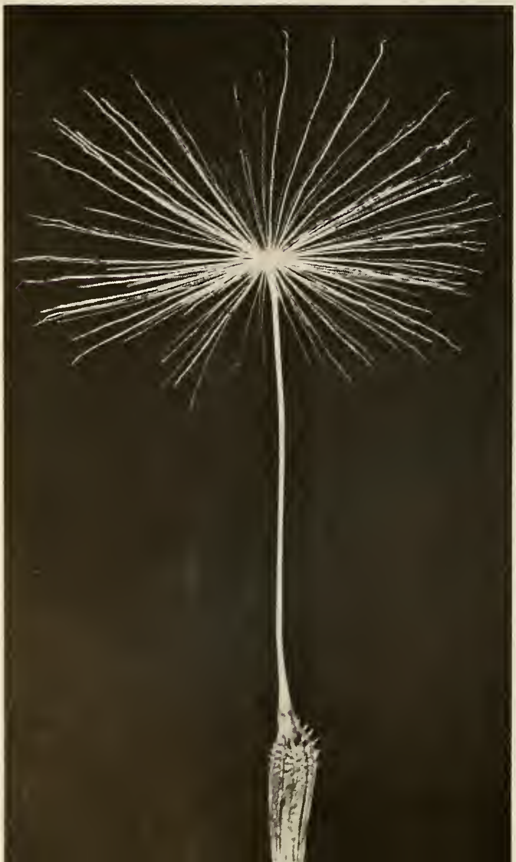




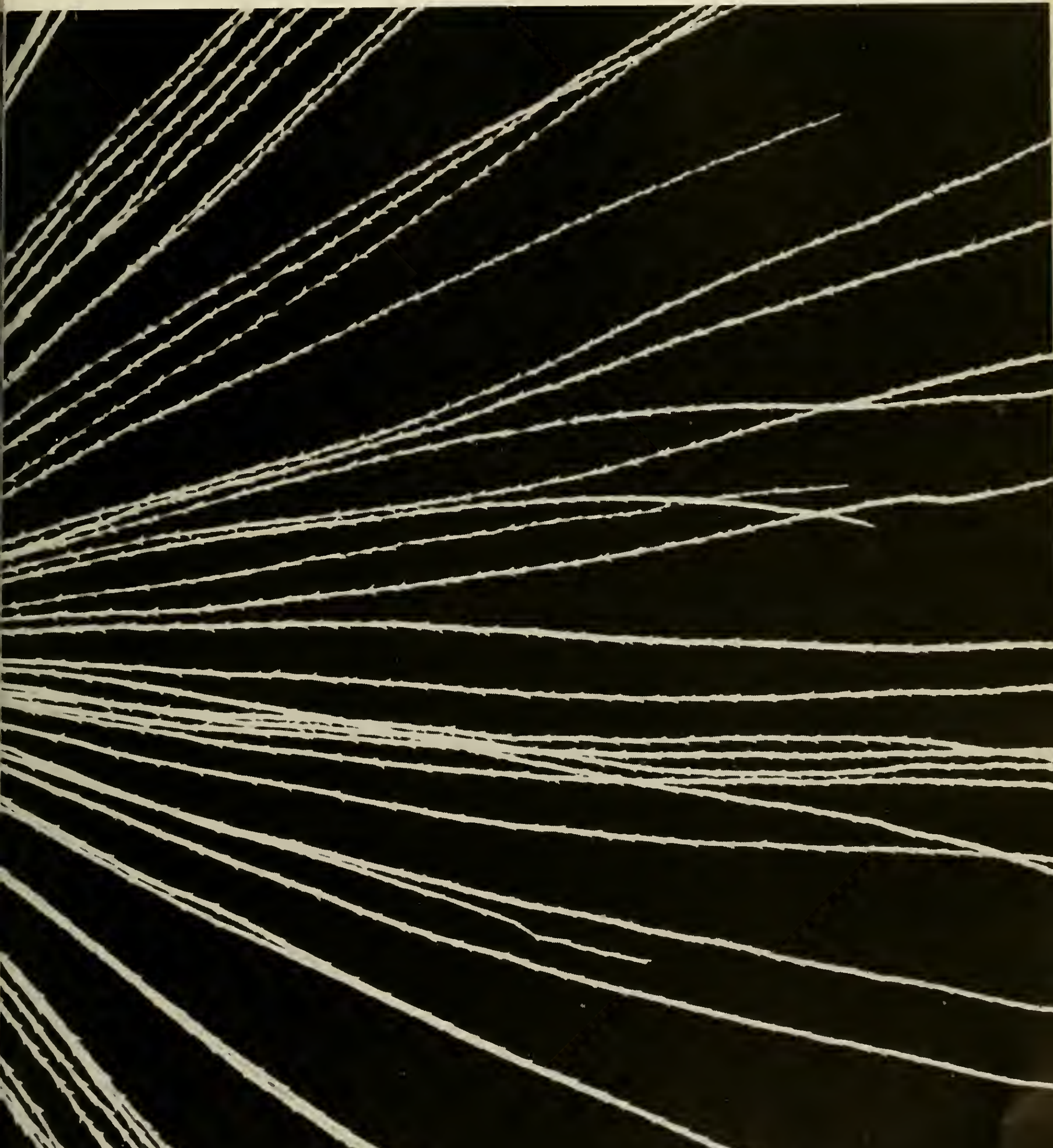
ONGITUDINAL SECTION of flower head ıows ovaries at the bottom, topped by raceful hairs that make up the pappus.

Two WHITE NUCLEI gleam in the cavity of a minute portion of single ovary's center. This magnification is 2300X.





Mature pappi, *above left*, form clock that vanishes as the wind detaches and disperses seed-bearing pieces, *at left*.



MULTITUDE OF HAIRS radiate from the center of pappus. Here, at one time, all of the flower parts were attached.

BRIDEGROOM, wearing a leopard skin over cowhide cape and carrying an oryx horn, is accompanied by men and women of his village as he sets out for neighboring enclave where his arrival is awaited by his bride-to-be and all of her relatives.

Marriage Economy: The Karamojong

Rites establish status of both bride and groom through barter

By Rada and Neville Dyson-Hudson

A man of the Karamojong tribe of northeast Uganda can say of a woman "I like her," or "I want her." But the expression "to love," with its complicated romantic connotations, is absent from their language. This does not mean that genuine attachments between men and women are absent from this herding society. Sexual interests and attachments are as intense among them as they are in our own culture. But for the Karamojong, these interests are viewed in terms of eventual marriage; and marriage is not only the emotional union of two persons; it is also a more general social union between two groups of people.

Never to marry is considered by the Karamojong to be a great personal misfortune that afflicts only those physically crippled, mentally sick, or poor to the point of destitution and dependence on others. For a man, particularly, marriage is of the greatest social and economic importance. It is the means of founding a family, which gives him status in the community; it is the means of providing himself with a larger group of relatives (his wife's), who will help him in trouble or in disputes with others.

Before a man even thinks of marriage, however, he must first consider

Relatives of the bride and groom sit on stools in the shade and argue over livestock in ritual that is almost economic blackmail. Plume-carrying spokesman for groom pleads poverty, insisting that the bride's people lessen demands.

his cattle resources and then survey the number of people who are closely related to the girl he has chosen, for each close relative of the bride must receive one or more animals on her marriage: a cow, an ox, a donkey, or at the very least a goat or sheep. Thus, a poor man may marry a girl with only one brother, and five cattle may perhaps be all the bridewealth he needs to give. But a rich man would rather choose a girl with many relatives, since he thus acquires a large number of supporters. He may give 200 head of stock to the bride's relatives.

When a young man sets his mind on marrying a particular girl, and has to

Blood and milk are mixed with fat in wooden bowl at bargaining sessions. Members of the parties drink mixture, followed by liberal portions of beer.

consider exchanging cattle for her, there are other persons who must be brought into the discussion. Older Karamojong often have several wives. Each wife and her children make up one unit in a complex family. The head of the family is the husband of all the wives, the father of all the children, and the owner of the livestock herd that provides the family with its main food. The prospective husband thus must discuss his choice with other men of his family. Most important are his father, as owner of the family's livestock, and his brothers, as members of the family unit that will share the herd upon their father's death.

EVEN if a man has his own independent herd, he may not marry without consulting his father or, if his father is dead, his oldest paternal uncle. This is because marriage joins not just two individuals, but two entire groups. Taking a wife thus means taking a whole set of in-laws; and it is almost as important for the in-laws to get on well together as it is for the husband and wife. For the Karamojong, the choosing of a wife agreed to by the head of the clan is particularly important, because a man's clan must look after the widow and family, should he die, by finding her a new husband from within the clan. A further virtue of having an older man make the final decision is that he can decide dispassionately whether the cattle left in the herd after the dispersal of wedding gifts are sufficient to support the young man and his new bride, in addition to any other wives and children he may already have.

Most often, a girl accepts her father's choice of husband—usually the man who can offer the most cattle. It is to her advantage to marry a man wealthy in cattle, since she and her children will then have ample food. But this is not always the case.

Longolio was a very wealthy man, with seven wives and seventy-two liv-

DURING THE BARTERING, bride is hiding in hut. Boys and girls go to drag her out, *above*, and, while she protests, *far left*, she must not be too adamant, or it will be taken by relatives on both sides as refusal on her part to complete ceremony.

Two of groom's relatives lead bride away to his village, accompanied by the rest of the party. Procession is noisy, and includes ritualistic shouting to herald their approach, which always concludes with entrance through cattle corral.

ing descendants. His second wife was a tall, strong woman who had nine children, all of whom survived. Her oldest daughter, Apuun, was very like her mother. Three wealthy men wanted to marry the girl, and one offered her family 200 cattle. She herself was attached to a young man with very few cattle. Apuun refused her father's choice and threatened to hang herself if she were forced to marry him. Finally, after much quarreling, tears, and recriminations, she was allowed to marry the poor man, and her family received only ten head of stock. Her brothers still, several years later, speak with disgust of the few cattle they obtained. But Apuun is happy and regularly visits her family, who receive her with cordiality.

If a marriage is likely to occur, the next step is for the bridegroom to visit his relatives and friends to collect any additional livestock he may need, for his father's herd or his own often cannot provide them all. He carries an oryx horn with a cow's tail on the end —a symbol that clearly announces the purpose of his visit, even before he opens his conversations with the conventional: "I have come to beg."

It may take the prospective bridegroom many months before he succeeds in amassing all the stock he requires. A father's brother in one area may give an ox; a mother's brother in another part of the country may contribute a heifer; one friend gives a goat or a sheep; another may even give a donkey. When the begged stock and those from his own family's herd suffice, he goes to the girl's home to tell her parents that he is ready. With the girl's father, he informally runs through the list of her relatives, enumerating animals that will go to each person. A wedding day is fixed, and the man returns to tell his relatives.

Bride and groom are blessed by her father and smeared with sacred clay.

Groom, with his father and brothers, counts cattle to be distributed, *right.*

As in our society, the women are ›re interested in the bride than in y other aspect of the arrangements. ›r the Karamojong women, the big-st festivities are connected with tching the bride to the groom's vil-ge. All the bridegroom's friends and latives gather in his village on the orning of the wedding. The women ease their hair and powder it with ılverized black iron oxide, gathered om the distant mountains. The girls ash their beads, clean them with dry eal, and grease them until they spar-e. The married women smear their ›ck wires with milk fat and grease eir necks and chests. The women one section decorate their faces ıd bodies with colored mud, spotting emselves like the giraffe, the animal at they revere. The men wear ostrich athers and leg bells; the groom wears leopard skin, a cowskin cape, and ırries an oryx horn.

Everyone then sets out for the bride's village, the men leading. Each woman carries a straight stick to symbolize that the marriage will be straight and good. They go single file down the narrow paths that connect villages to each other, the women shouting and dancing as they go. They may imitate a giraffe, an elephant, or a river, depending on the tribal section.

"Wha-wha, wha-wha, wha-wha," they cry, mimicking the neighing of a zebra. The sound carries a long distance, announcing to all that they are coming to fetch a bride.

The high spirits of the groom's party are ostensibly dampened when they arrive at the bride's village, for the bride's male relatives feign complete indifference. They sit beneath a tree and talk unconcernedly as the groom's friends and relatives enter the stockaded village through the cattle corral, remove their shoes, and wait. The women in the village carry on their tasks, pretending not to notice the large party of intruders sitting outside their compounds.

Finally, the guests are invited into the compound of the bride's mother. They enter barefooted, the stools they carry are taken from them, and they are seated on the ground in the hot sun. The bride's male relatives are then summoned by the groom's brother. They keep their shoes on, file soberly into the compound, and sit in relative comfort on stools in the shade. The two parties greet each other formally.

Although the number of cattle going to each relative has been generally agreed upon between the bridegroom and the bride's father, this is an opportunity for the bride's relatives to try to get a few more. The father of the bride rises from his stool. "I speak of cattle," he gravely tells the groom and his friends—and then enumerates relatives

CLAY PIPE is smoked in an elaborate ritual involving all of the participants.

and lists the stock they must receive upon his daughter's marriage.

The most vocal of the groom's relatives rises to reply. "Father, our cattle are few. The sickness which is in the land—it has killed our stock. Only a very few remain. Our herds are now but a few donkeys."

Both these are pieces of rhetoric, because the actual hard bargaining is done elsewhere. But they show quite clearly that Karamojong marriage is basically the exchange of cattle for women, involving negotiations that come close to being economic blackmail. The bride's family pushes for all the stock it can get; the groom's relatives give as little as they can without being overtly insulting.

THIS formality completed, the wedding feast begins. Blood and milk are mixed in a large wooden bowl, fat is added, and each person in turn is called to drink. Then beer is drunk in the huts, and the discussion of cattle is continued. The father of the bride, made even more vociferous by beer, repeatedly names the members of his family who must receive stock, and points out how seriously offended they will be if they receive an inadequate allocation. The mother of the bride does the same thing.

During this whole period, the bride is nowhere to be seen. She has been hiding in another hut in the village. The boys and girls who have been drinking with the groom's party go to search for her. When they find her, the owner of the hut may protest and refuse to let the boys and girls in until the bride has been promised a sheep or a goat. Finally, the girl is dragged struggling from the house and into the yard where her parents are waiting with the groom and his relatives. It is customary for her to protest and look unhappy, and to weep at the thought of leaving her home to live with strangers—but she must not resist too strongly. Too violent a protest may be taken as a refusal to go through with the wedding.

The bride's father blesses the couple by smearing them in turn with sacred gray clay. "Beget many children," he says. "May you grow old."

All the other people are then blessed, and their foreheads and chests are smeared with clay. Two of the groom's party take the girl's hands and lead her away. She goes reluctantly, looking back at the other village girls she is leaving behind.

"Wha-wha, wha-wha, wha-wha," the groom's relatives shout again as the bride leaves her village. "Wha-wha, wha-wha, wha-wha," they shout as they approach the groom's village, which is to be her new home.

As the people enter the groom's village through the gate of the cattle corral, they are blessed by being sprinkled with water, and the ceremony is finished for the day.

Meanwhile, the groom makes sure that all his cattle are present, ready for the giving of the bridewealth on the following day. All the bride's relatives arrive the next morning, and wait outside the gate of the cattle corral for

CO-WIVES AND SISTERS-IN-LAW of bride each remove a neck wire and present it to the new relative as marriage symbol.

GOATSKIN SKIRT AND APRON signifying marriage are donned by bride, *above*, who then is smeared with milk fat, *right.*

e stock to be driven out. The groom f he has his own herd) or his father f the groom is still a dependent) will pervise the distribution. The men ide through the corral, often knee-ep in wet dung, selecting cattle, sepa-ting them from the herd, and driving em out to the waiting family.

"Drive out the cows of the father," outs the bride's family from outside e corral, and the promised animals e driven out, under critical eyes.

DRIVE the cows of the mother," they call, and beasts that have been greed upon are cut out from the herd the corral and driven out to the aiting crowd. And so it continues. he cow of the grandmother and the randfather, of the mother's brother nd the father's sister, are all driven ut. The husband of the bride's older ster should receive ten head of stock. distant uncle may get a goat. Gen-al standards of suitable stock are nown to everyone. But even at this age, the bride's family will try to get ore cattle than have already been romised. They "remember" some for-otten, distant relative, and demand n animal for him. Or if an animal at has not been selected as a gift reaks away from the herd and tries leave the corral, the bride's rela-ves encourage it with cheers, and are

For three years Dr. Dyson-Hudson, with her husband, Neville, lived with Karamojong and photographed them. She lectures at Khartoum University.

ready to claim it as an extra contribution if it escapes. Meanwhile, the groom or his helpers hasten to head it off. If the animal does succeed in escaping, a long discussion ensues. The bride's party insists it is theirs, the groom's party tries to get it back. Even the bride, watching from the compound near the corral, can interfere in these discussions, and ask the groom to give more cows to a particular relative who has been good to her.

After all the bride's relatives have been satisfied, the close relatives of the groom return with them to the bride's village. There they sit on a white cowhide sleeping mat and smoke tobacco with careful ritual. A clay pipe is filled by an old woman of the bride's family and given to the bride's father. When he has smoked, the ash is emptied and rubbed into the cowhide; the pipe is then refilled and given to the groom's father. Next the groom smokes, and the pipe is passed to his mother-in-law.

After the pipe-smoking, the groom and his party arise and dance slowly and formally on the hide. Others join in, and soon everyone is dancing—often in the cattle corral. The people are then invited to the compound of the bride's mother, where beer is served. This amicably concludes the exchange of cattle between the two families and the transfer of a woman from one family to the other.

A man is very careful not to show favoritism among his wives. If there is quarreling between wives, he beats them both, to discourage future trouble. For similar reasons, he avoids having a new wife with the junior wife she has just displaced. If he has two wives, the new bride is put in the compound of the senior wife until she gets her own compound built. If there is only one wife, the bride stays in a hut in her mother-in-law's compound. Although romantic love is not important among the Karamojong, sexual jealousy among co-wives is a commonly accepted feature of life. So, after the formal wedding ceremony—the exchange of cattle between the two family groups—is completed, there still remain domestic ceremonies by which the bride is formally incorporated into her new family association.

The groom has returned to his village after the pipe-smoking ritual. When the cattle return in the evening, the groom calls his new wife to the milking enclosure of the corral and tells her to milk the cow he has chosen for her. The milk from this cow will

HAZING of bride includes making her carry water in tiny pot, which is then deliberately knocked from her head by attending women from groom's village.

always be hers. He sits on his stool and watches her; after she has finished milking, the other women tell her to remove the groom's marriage ornaments. Shyly, she approaches her new husband and takes from him the leg bells, shoes, and oryx horn he has carried during the wedding ceremony. She takes all these to her hut, and sleeps with them by her side. Her husband does not sleep in the same hut with her until all the domestic ceremonies have been completed.

THE following morning, all the women and girls gather in the compound where the new bride is staying. A white cowhide is pulled out of the hut for the bride to sit on. Her beads, worn only by unmarried girls, are removed. The married women—co-wives and sisters-in-law—then take off one of their own neck wires or earrings, which symbolize their married status, and put it on the new member of the family. The co-wives have prepared new clothes for the bride, and the small sheepskin skirt and bead apron that she has worn as a single girl are exchanged for the goatskin skirt and apron of a married woman. She is then blessed by being smeared with milk fat by the co-wives.

The bride must then be shown the three important domestic tasks of the women: collecting wood, fetching water, and grinding grain. This gives her a chance to get acquainted with the village girls, who use the ceremonial to indulge in mild hazing.

First, the girls take the bride to find wood. They leave early and go a long distance to find a particularly large and tough log. After chopping it a few times with their axes, they tell the bride to finish the job. When this task is completed, they return to the village, entering through the cattle corral.

Next they take the bride to fetch water. Each girl fills a water pot, but the bride is given only a tiny gourd. As they return to the village, one of the girls intentionally pushes the gourd off the bride's head.

BRIDE and one of her co-wives grind sorghum together as part of ceremony.

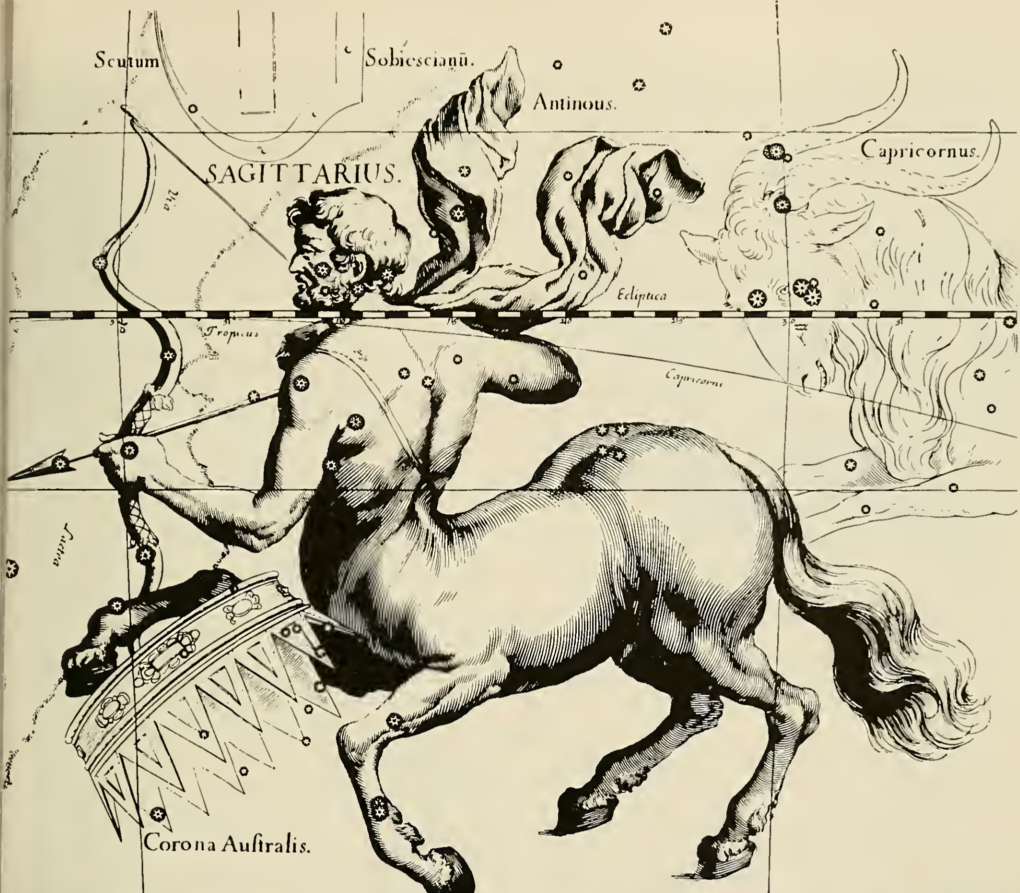
"OH dear! Oh dear! I have broken my mother's thing," the bride cries in mock alarm, and the other girls laugh. Once again, they return to the village through the cattle corral.

Finally, a grindstone is made ready for the bride. Another woman holds the pestle with her, and both grind some sorghum. Then the bride finishes the grinding by herself.

The final stage of the hazing is "making the bride fly." The boys all get long, thin sticks, and wait inside the gate of the corral as the bride and the other women go once around the village. When they enter through the corral gate, the boys beat them — not only the bride, but any woman who has been troublesome to them. The women flee to their huts, leaving the boys laughing in the corral. The wedding ceremony is now completed.

It would seem that the man has everything to gain by marriage. He acquires kinsmen, he begets children, yet he loses none of his freedom to come and go as he pleases. In this polygamous society, any interest he shows in other girls cannot be condemned, for it can always be interpreted as a preliminary to taking another wife. For a girl, marriage would seem less desirable. She gives up the carefree life in her father's village and becomes a menial in her husband's village. She must wait on her husband's mother, sisters, and other wives, and behave in a docile and demure manner. She gives up the freedom of going to dances (where she is courted by and flirts with boys from surrounding areas) and restricts her attention to one man who, if he has several wives, may neglect her part of the time. Yet, although the girl apparently has everything to lose and the man everything to gain, it is often the girl who chides her lover, and the young man who is reluctant to marry. The reason is perhaps that Karamojong society is very much a man's world. Women are all looked after, the very few unmarried ones are cared for by their fathers and later by their brothers. But although a woman would always be provided for as a daughter and sister, it is only as a wife and mother that she finds a secure place and respected status among her people.

"MAKING THE BRIDE FLY" is final step in hazing. Boys of groom's village, carrying long, thin sticks, beat not only the bride, but other women of party, all of whom flee from them. This play completes the ritualistic wedding pattern.



:ONSTELLATION SAGITTARIUS, ninth sign of the zodiac, is lepicted as centaur drawing bow in a sketch from Hevelius' *Prodromus Astronomiae et Firmamentum Sobiescianum.* Area of Sagittarius is most dense of all fields of Milky Way.

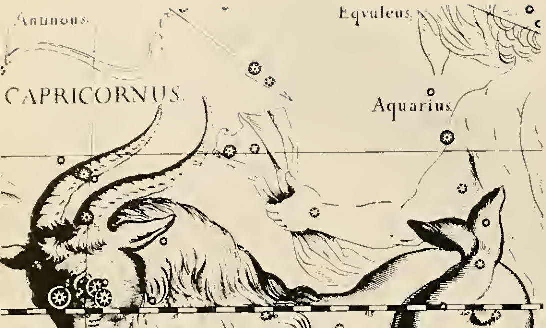
SKY REPORTER

Diversity is the hallmark of the southern zodiac's constellations

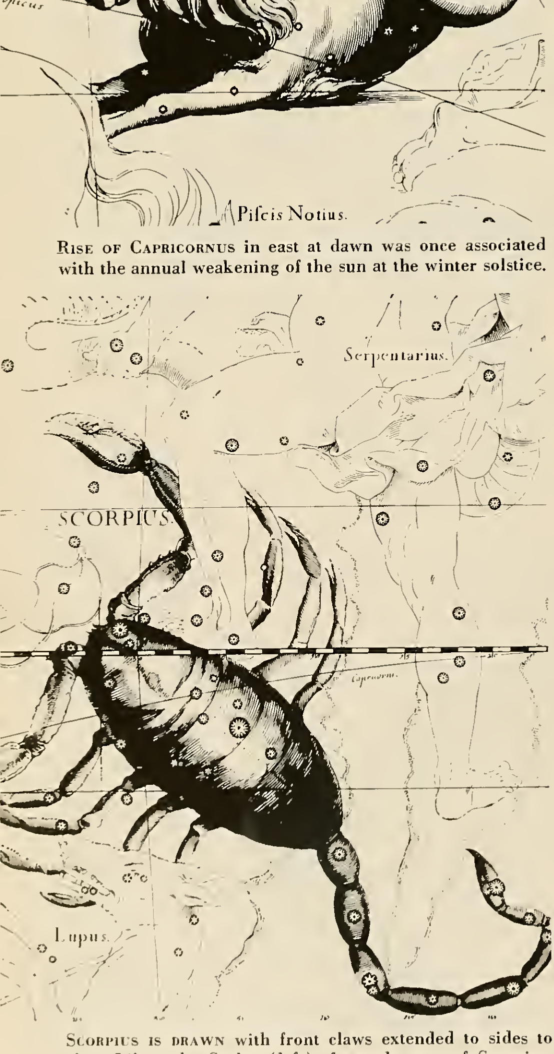
By SIMONE DARO GOSSNER

THE SOUTHERN ZODIAC, from Virgo to Aquarius, is a study in contrasts. The area covered by Virgo and the ıeighboring constellation, which is named Coma Berenices, :orresponds to a direction in space where there is relaively little obscuration attributable to interstellar dust. The terrestrial observer is looking away from the plane of he Milky Way (where cosmic dust prevails) and can see :lear through to the rich fields of galaxies—huge star sysems like our own—far out in the universe. In Scorpius and Sagittarius, on the contrary, the observer is looking directly n the plane of the Milky Way and sees an extraordinary ırray of gaseous nebulae and star clusters embedded in a nultitude of faint stars. As a final contribution to diversity, Aquarius stands as an almost forgotten relic of some of man's most ancient mythologies.

Of the many thousands of galaxies in Virgo and Coma, it has been found that a large number constitute an enormous cluster that is the largest such association yet detected. The brightest of these cluster members—about 30 of them—are approximately of the tenth magnitude; thus they must be viewed with at least a six-inch telescope. Larger instruments reveal nearly 3,000 galaxies between magnitudes 10 and 12.5 (astronomers have lost count beyond this). The densest region of the cluster lies approximately at the center of the triangle formed by the bright stars Regulus, Arcturus, and Spica. The average distance from earth of its members is currently estimated at 13 million light-years. To express this in miles, one would have to write 76 followed by 18 zeros; although inconceivably large by everyday standards, this distance happens to be a short one within the universe (the 200-inch Palomar telescope has photographed galaxies to about 4 to 6 billion



Rise of Capricornus in east at dawn was once associated with the annual weakening of the sun at the winter solstice.



Scorpius is drawn with front claws extended to sides to clear Libra, the Scales (left), formerly part of Scorpius.

light-years—so far, in fact, that the instrument's exact reac cannot be estimated accurately at present). Actually, th Coma-Virgo cluster is so "nearby" that the local grou formed by our own Milky Way and a few neighborin galaxies might well be an extension of it.

Not counting our local group, however, the cluster as whole is receding from us at an average speed of 700 mile per second, although the speed of recession of its individua galaxies varies considerably from one to another. If, as w think, the cluster is truly a physical entity, its member have probably some internal motions (such as around a common center, for example). Unfortunately, only th speeds of recession—that is, the motions in our line of sigh —can be analyzed; all galaxies are too far away to exhibi any measurable displacement across the celestial sphere Therefore, astronomers are unable to deduce their true space velocities. With present methods, astronomers would have to accumulate observations for tens of thousands, and perhaps for several hundreds of thousands of years before they could solve this tantalizing problem.

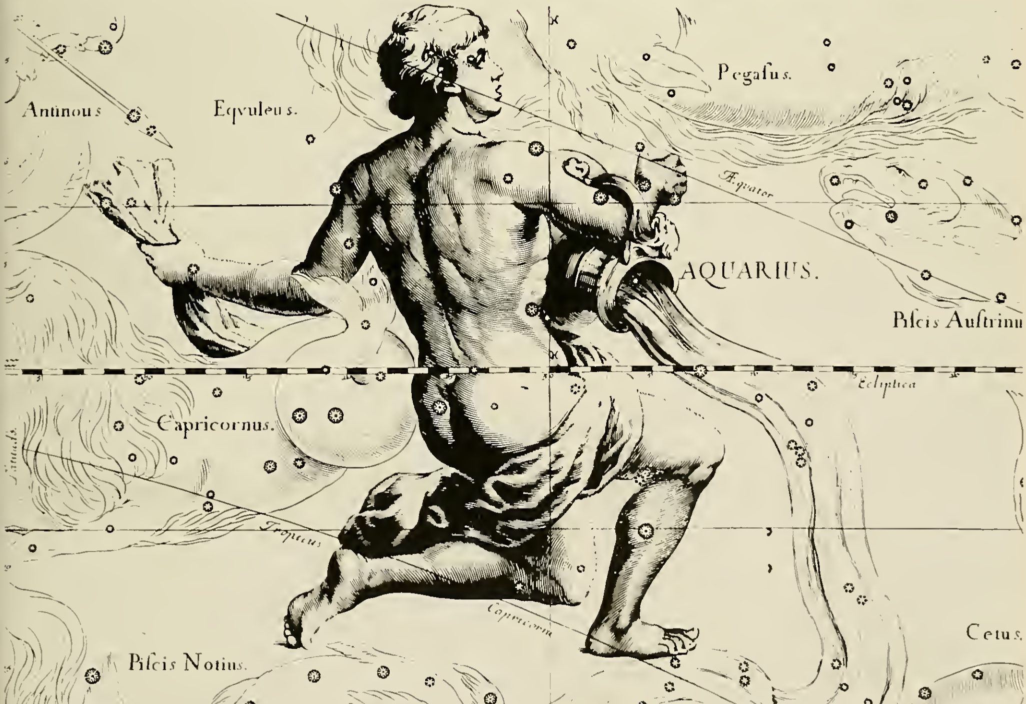
Fourteen years ago, when radio astronomy was still in its early stages, the Australian astronomer John C. Bolton announced the discovery of a source of strong radio emission located somewhere in the Coma-Virgo area. A few months later, more precise measurements indicated that the radiation was coming from an unusual-looking galaxy known as M87 (that is, the 87th object listed in Messier's catalogue of nebulae and clusters). Renamed Virgo A according to the nomenclature of radio astronomy, M87 distinguishes itself by the possession of a curious luminous jet protruding from its otherwise elliptical shape. This jet feature is as yet unique; if any other galaxy is similarly endowed, it is still beyond the range of today's instruments. Although optical observations can tell us no more, a detailed study by radio telescopes has revealed that M87's jet is radiating in a manner completely similar to the supernova remnant called the Crab Nebula (Natural History, April, 1962). However, the Crab's diameter is only about three light-years, whereas the jet extends over some 300 light-years. On the other hand, the amount of radiation per unit volume is essentially the same in both. Only one conclusion imposes itself at the moment: the cosmic explosion that caused Virgo A's mighty jet was still 100 times more powerful than the one from which the Crab was born.

Whereas the Coma-Virgo region represents an extreme concentration of galaxies, the area encompassed by Scorpius, Sagittarius, and the neighboring constellation of Centaurus yields the densest agglomeration of nebulae, interstellar material, and faint stars to be found on the entire celestial sphere. The material is so concentrated and so opaque that not a single one of the distant galaxies can be seen through it. It is hardly necessary to add that the area lies squarely in the belt of the Milky Way, for it is precisely such concentration in the line of sight of numerous faint stars and patches of nebulosity that gives the Milky Way its characteristic appearance. A few decades ago, it was noted that the region diametrically opposite Sagittarius is the least dense of all Milky Way fields, whereas Sagittarius is the densest. Since most galaxies are known to have a nucleus thickly populated with stars, it seemed natural to conclude that Sagittarius must lie in the direction of our Milky Way's own nucleus. Recent observations have amply confirmed this assumption.

THE relative dullness of Aquarius as a hunting ground for telescopic objects is remarkably compensated for by its mythological interest. It is probably one of the oldest stellar configurations; its ancient name was Mulgula, "The Great Constellation," symbolic of An, the sky god of the Sumerians. Through the ages, the water-pouring figure took on many faces as mythological tales evolved from one civilization to another. In the days of the Roman Emperor Caesar Augustus, a freed slave named Hyginus (first century B.C.) recorded many of the constellation legends in his *Book of Fables*, which has remained a classic on this subject. Of Aquarius he wrote: "Many have said that he is Ganymede, who, it is believed, was stolen from his parents by Jupiter because of the beauty of his body, and made an attendant of the gods. Therefore he is shown pouring water to someone. Hegesianax also says that he is Deucalion because, during his reign, a deluge of water fell so abundantly from the skies that, it is said, a cataclysm ensued. Eubalus also demonstrates that he is Cecrops commemorating the antiquity of his family and showing how water was used in sacrifices to the gods before wine was known to men."

Of these attributions, the reference to Deucalion is most interesting. Heavy floods were frequent in Mesopotamia during Babylonian times, and the primitive terror that they must have generated is reflected in many ancient tales as memories were handed down from generation to generation. Whether or not the same flood inspired the story of Deucalion and the biblical account, one cannot say, of course. But a point worthy of note is that the symbolism of so many of the ancient constellations seems to involve water, sea monsters, and long sea voyages: Eridanus, possibly a symbol of the great river Euphrates, on which the Sumerian goddess Inanna sailed to the city of Eridu and its nearby abyss; Cetus, the monster that Inanna's Babylonian counterpart, Ishtar, summoned from the sea (we now call Cetus a whale, but the Babylonians never saw such an animal); Hydra, the water snake; and finally, the good ship Argo, on which Jason sailed in quest of the Golden Fleece. It has been noted by some that Jason's story has many points of similarity with that of Noah and the Ark—an association that leads back to Deucalion and Aquarius.

WE would be tempted to make short shrift of Capricornus and Libra, which have few telescopic objects of interest and even fewer mythological connotations, were it not for the privileged position they once occupied in relation to the seasons. Two thousand years ago, when the zodiacal constellations were still found in their corresponding sign, the sun was at the autumnal equinox when Libra was seen rising in the east at sunrise; and it was at the winter solstice when that function was assumed by Capricornus. The superstitious fears caused by the annual ebbing of the sun's strength in the winter, coupled with harsher weather conditions and a temporary halt in agricultural activities, undoubtedly led ancient soothsayers to associate evil with celestial events in "Capricorn."



ANCIENT NAME of Aquarius was Mulgula, which meant "The Great Constellation." This figure depicting a water-pourer symbolized An, the Sumerian sky god, but it assumed other guises as myths evolved from one civilization to another.

THE SKY IN MAY

From the Almanac:

New Moon	May 3, 11:25 P.M., EST
First Quarter	May 11, 7:45 A.M., EST
Full Moon	May 19, 9:32 A.M., EST
Last Quarter	May 26, 2:06 P.M., EST

For the visual observer:

Mercury, in the evening sky, will set 90 minutes after the sun on May 1, two hours after on May 15, and 45 minutes after on May 31. It will be most favorable for observation at midmonth because it will be at its greatest eastern elongation (22° east of the sun) on the evening of May 13. However, it should be visible, low in the western sky, for most of May. It will be at its brightest (—0.7 magnitude) on May 1 and will fade gradually to +2.4 on May 31.

Venus, also in the evening sky (—3.4 magnitude), will set two hours after the sun on May 1, two hours and 15 minutes after on May 15, and two and a half hours after on May 31. Observers should experience no difficulty in finding this brilliant object low in the western sky in the early evening hours throughout the month.

Mars, in the morning sky (+1.4 magnitude), is still quite close to the sun. It will rise in the east one hour before sunrise on May 1, one hour and a half before on May 15, and one hour and 45 minutes before on May 31. Mars may be found low in the eastern sky shortly before sunrise.

Jupiter, in Aquarius (—1.8 magnitude), will rise in the east at approximately 2:30 A.M., local standard time, on May 1, at 1:45 A.M. on May 15, and at 1:15 A.M. on May 31, and it will appear in the southeastern sky at dawn.

Saturn, in Capricornus (+0.8 magnitude), will rise at approximately 1:15 A.M., local standard time, on May 1, 12:15 A.M. on May 15, and 11:15 P.M. on May 31, and will reach the southern sky shortly before sunrise.

The Eta Aquarids meteor shower will reach its maximum intensity on the night of May 4 to 5. Barring inclement weather, circumstances will be favorable for observation because the moon will be only one day past new at that time. In past years, the Eta Aquarids have reached a maximum of 20 meteors per hour (for a single observer).

Absolute magnitudes:

The apparent brightness of a star or planet depends in great part on the distance of the object. For certain astronomical studies, on the other hand, it is useful to be able to compare the true brightness of stars to one another—that is, the brightness each one would display if all were at the same distance. By convention, astronomers compute how bright a star would be if it were brought to a distance of 10 parsecs, which simplifies the arithmetic involved. This is equal to approximately 32 light-years. The result is called the star's *absolute magnitude*—as opposed to its apparent magnitude as shown on star maps.

If we could see the celestial sphere rearranged in this fashion, it would look very startling indeed. The sun would be an inconspicuous +4.8 magnitude, requiring the smallest symbol on our map, and Arcturus would be taken down a peg to —0.3. By contrast, Capella and Regulus would be promoted to our largest symbol; Spica and Antares would be as bright as Venus; as for Deneb, at about —7, it would outshine all others and be able to cast noticeable shadows.

On the preceding pages, MRS. GOSSNER offers the fifth in her 1962 series — a survey of the celestial sphere.

To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.


north
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
CASSIOPEIA
PERSEUS
northwest
CEPHEUS
CAMELOPARDALIS
CAPELLA
AURIGA
POLARIS
NORTH POLE
LITTLE DIPPER
URSA MINOR
LYNX
VENUS
31
CASTOR
GEMINI
POINTERS
BIG DIPPER
ALCOR
POLLUX
CANES VENATICI
URSA MAJOR
LEO MINOR
ZENITH
Praesepe
CANCER
CANIS MINOR
PROCYON
west
COMA BERENICES
ARCTURUS
11
REGULUS
LEO
14
VIRGO
SPICA
HYDRA
CRATER
CORVUS
PYXIS
ANTLIA
southwest
CENTAURUS
TIMETABLE
May 1 10:00 P.M.
May 15 9:00 P.M.
May 31 8:00 P.M.
(Local Standard Time)
south

Sanctuary of the gods at Samothrace

ANTIQUITY TODAY

Greece and its islands offer the visitor new echoes of the past

By James Burke

In the fall of 1961, on the small, sun-drenched Greek island of Delos, legendary birthplace of Apollo, a group of Frenchmen gathered excitedly around a freshly dug trench. Faintly etched at the bottom was the trace of a wall that marked the remains of a house dating from the eighth or ninth century B.C.

A few weeks earlier, these men, members of the French School of Archeology in Athens, had found a number of sacred buildings that dated from the second century B.C., including one with a well-preserved mosaic floor, and frescoes that depict sacrificial offerings.

These happenings on Delos, already the site of the most extensive ancient ruins in the Aegean, are being repeated in varying degrees throughout present-day Greece, for archeology here is in high gear. American, German, French, English, Italian, Swedish, and Greek scholars are digging from Pella, in Macedonia, to Pylos, in the southern Peloponnese, as well as at many island locations.

All this current activity may surprise the casual visitor who thinks of Greece as long rediscovered, its Parthenon and other noble monuments fully laid bare to tourist view. It is true that Heinrich Schliemann dug at Agamemnon's Mycenae more than eighty years ago, and Arthur Evans unearthed the Minoan palaces of Knossos, on Crete, at the turn of the century. But it is also true that the first decipherment of Linear B, one of the two Minoan scripts that baffled Evans and others, was made by Michael Ventris only ten years ago (Natural History, March and April, 1961). Actually, archeology in Greece is almost in its infancy. Many pieces have been found, but missing parts are turning up all the time. One of the pleasures of visiting Greece, is that there is always something new to see among the old ruins.

The most dramatic recent discovery was made some two years ago by Greek laborers who were repairing a sewer in Piraeus, the port of Athens. As their picks bit down under the street, one of them struck metal, and before the end of the day the Greek Department of Antiquities was called in to take over a priceless cache of bronze sculpture. Of the eight works found, the most notable were four statues: a magnificent *Kouros* (young man) from the late sixth century B.C., and fourth century B.C. figures of Artemis, Athena, and a young woman.

How they got there and why they had not been found earlier remain a mystery. Some scholars have theorized that they may have been part of a shipment of artistic loot destined for Rome, and that the warehouse containing them was burned when Athens and Piraeus were attacked by troops of Sulla in 86 B.C.

The bronzes are now in the workrooms of the National Museum in Athens undergoing restoration. This is a long and tedious process of removing corrosion and soil particles by washing in distilled water (a special distilling plant had to be imported from Germany to make the quantity needed), and by careful brushing, without damaging the main surfaces of the statues. The museum hopes to have at least the *Kouros* ready for pub-

A photojournalist, Mr. Burke spent years living and traveling in Greece.

lic display sometime in 1962, and it will unquestionably rival two celebrated bronze sculptures of ancient Greece: the "Zeus" (or "Poseidon," as some authorities refer to it) in the Athens museum, and the "Charioteer" in the museum at Delphi. Marble statues from ancient times are plentiful enough, but bronzes usually went into invaders' melting pots.

All the principal museums in Greece have recently been and are still being enlarged and redesigned to make way for new acquisitions and to improve display technique. The new sculpture halls that opened in the National Museum in 1961, for example, are arranged to show the development of the Greek representation of the human form from Egyptian-influenced massiveness of the preclassical period to the warm humanism of the fourth century B.C. artists.

In the Athens Acropolis Museum, three new halls are devoted to the archaic (mostly sixth century B.C.) sculpture that survived the Persian destruction of the earlier Acropolis monuments, but was buried under the foundations of the Periclean reconstructions. Thus protected from the weather, these works have retained much of the coloring that the Greeks habitually applied to their marble art—a revelation to those who think Greek sculpture was as pristinely unadorned in the original as it appears now.

In northern Greece, Alexander the Great's birthplace and first capital at Pella, near Salonika, has been providing rich finds for the Greek Archeological Service since excavation began there in April, 1957. Before the first trial trench was sunk at the traditional site of Pella, a flat stretch of farm land, there was not a trace aboveground of the city that launched the conqueror of the ancient world. Yet within a year enough was found to indicate that Pella once covered an area of at least 4.800 square yards. Some of the royal palace buildings had walls six or more feet thick. Others had rooms decorated with fine. colored pebble mosaics, including one spectacular 80-foot-square design that shows a naked Dionysus riding on the back of a panther. Another equally fine mosaic represents two almost nude hunters attacking a lion. Restoration of the structure called Building No. 1, which contains these unusual mosaics. is now under way, and work on the columns of the structure's peristyle is nearly complete.

In 1958 the Greek society discovered the site of the ancient Nekromantion (oracle of the dead) of Acheron in the northwestern province of Epirus, on top of a hill overlooking the dried-up bed of the Acherusian lake. The oracle building, dating from the middle of the fourth century B.C., led to a labyrinth that supposedly opened into Hades. Among the objects found on the oracle site were

Colored pebble mosaic in Building No. 1 at Pella depicts two almost nude hunters

ritual basins, many amphorae, an earthenware statuette of Persephone (goddess of the underworld), and a small idol depicting Cerberus (watchdog of hell).

The province of Epirus also contains the site of the more famous oracle of Dodona, which was mentioned in Homer and was the original location of the Zeus cult. The sacred oak tree, which signaled the chief god's presence with rustling leaves, had disappeared long before Alaric's Goths destroyed the place in the fifth century A.D., but the stone-built theater nearby fared better. It was cleared of earth in 1959, and one year later a revival of ancient drama was staged in it. Delphi, greatest of all the old oracles, also has a restored open-air theater that is used occasionally; and the Roman theater of Herodes Atticus on the slopes of the Acropolis in Athens is the scene of the successful annual Festival of Athens in August and September. Among those appearing there during the 1961 season were the London Royal Ballet, Milan Chamber Opera, Berlin Chamber Orchestra, and Harvard Glee Club.

But the most spectacular attempt at revitalizing ancient theaters in Greece has been accomplished at Epidaurus. birthplace of the medical god *Asklepios* (or Aesculapius), and site of his famed healing shrine, the Lourdes of the ancient world. The shrine became a center of dramatic performances and games, and its incredibly well-preserved great open-air hillside theater, built in the fourth century B.C., can seat 14.000. It is acoustically remarkable: a match struck on the stage can be heard clearly on the top tier of seats, fifty rows up.

Last summer, as for the past six years,

attacking lion with spear and sword. Pella was the birthplace of Alexander the Great.

a festival of ancient drama was produced at the Epidaurus theater. featuring plays of Euripides. Sophocles. and Aristophanes. An additional attraction that season. Maria Callas and other top-flight opera stars appeared in two performances of Cherubini's *Medea*. At each presentation of the opera more than 16.000 spectators overflowed the ancient theater.

GERMAN archeologists in Greece have been concentrating most of their efforts at Olympia. where the original Olympic games were held every four years in honor of Zeus. The ruins of the vast Doric Temple of Zeus—where Phidias' forty-foot gold-and-ivory statue of the god once stood as one of the Seven Wonders of the World—have long been excavated. but work continues on the Olympiad stadium. The oval outline of the structure. clogged with earth before the present digging, can now be seen from the nearby motor road. The Germans hope to restore the stadium completely.

Another German team is working in the eastern Aegean on the island of Samos. celebrated in ancient times both as the birthplace of the philosopher Pythagoras and of the goddess Hera. Zeus's jealous spouse. One recent find there was a small wooden statue of a woman with her hair done in the archaic style of the sixth century B.C. An inscription indicates that the statue is of Hera. and the face bears a strong resemblance to that on the marble head of the goddess in the Louvre. In addition to its extreme rarity, a wooden carving of this antiquity is of exceptional interest for students of ancient Greek plastic arts.

Farther south and east across the Aegean on Rhodes, the garden island of

the Dodecanese, Greek archeologists began excavating last summer outside the old walls of the city of Rhodes, near the Bay of Acanthia. Among the finds was a mass grave containing forty-five skeletons. In the mouths of some were copper coins, doubtless intended to pay the dead men's fare to Charon, the ferryman who carried souls of the dead across the river Styx to the underworld. The skeletons are believed to be of people who died when Rhodes was besieged by Mithridates the Great, king of Pontus, in 88 B.C.

AMERICAN archeological activities in Greece have broader and more extensive fields than those of any foreign group. They range from Mycenaean excavations at Pylos—where Professor Carl Blegen found the Palace of Nestor, Agamemnon's venerable associate in the Trojan War—and the island of Kea, to investigations of the Byzantine layers of Old Corinth. Americans are also working at Isthmia, site of the ancient Isthmian games of Corinth.

In the spring of 1961, an American field team discovered a sanctuary of Demeter and Persephone, dating from the sixth century B.C. into Roman times, on the slopes of the Acrocorinth, the towering citadel of Old Corinth. There is also American activity on the northern Aegean island of Samothrace, where the "Winged Victory," now at the Louvre, once stood in one of the most important of all the shrines of ancient times.

The American School of Classical Studies in Athens was responsible for excavating the agora (civic center) of the old Greek capital some years ago, and for the complete reconstruction in 1956 of its stoa of Attalus. This roofed colonnade, one of several stoae originally in the agora, now serves as a museum. Documentation of the agora finds continues to occupy the school.

IN sheer numbers, of course, amateur archeologists surpass those in any of the professional groups in Greece. It is one of the charms of this unspoiled land that any tourist with a sense of the past can feel the thrill of discovery by poking around the edges of ancient sites. A bit of marble temple column hides under a thick bush. The torso of a statue lies half-covered by earth at the bottom of a trench that professional excavators have temporarily abandoned.

Recently, a skin diver rowed out near Cape Sounion and within minutes was swimming among the barnacle-encrusted amphorae from a third century B.C. shipwreck. Another amateur explorer diving off the island of Melos a few months later came up with a part of a marble hand. He called a press conference and announced to the world that he had found part of the missing arm of the "Venus de Milo." Professional archeologists were unimpressed, but a record number of tourist yachts visited Melos in the ensuing weeks, and skin divers flashed in and out of its clear blue waters looking in vain for additional fragments of the "Venus." But who can predict what Greece may yield in the years to come?

This list details the photographer, artist, or other source of illustrations, by page.

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37—AMNH after L. J. Kulp
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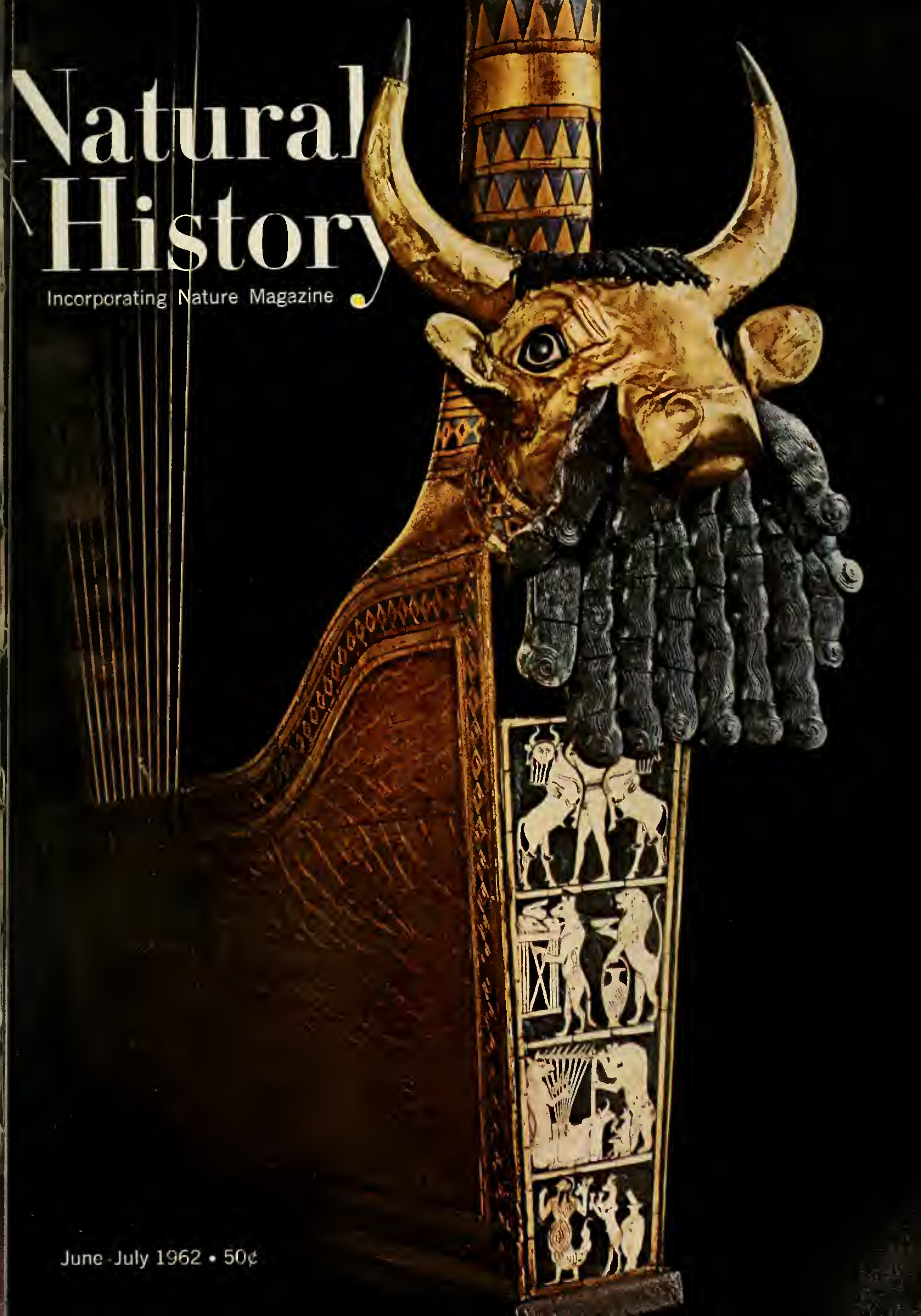
58-59—Sky Map after Henry M. Neely
61—Phyllis W. Lehmann, courtesy Archeological Research Fund, N. Y. U.
62-63—Photios Petsas

Natural History

Incorporating Nature Magazine



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COVER: Some 4,500 years ago, a harp decorated with this bull's head and shell plaque was made at Ur in Mesopotamia. The head is covered with gold sheeting, has inlaid shell eyes, and a lapis lazuli beard. The plaque, seen also on page 29, shows a man and two human-headed bulls, a dog and lion with meat and drink, a donkey and a jackal playing harp, sistrum, and tambourine while a bear dances, a scorpion-man and a gazelle holding two goblets. These beautiful pieces are exhibited at The University Museum in Philadelphia. On page 28 begins a study of animals in the ancient culture of the Sumerians.

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Reviews

Recent books scan the sky for heavenly data

By James S. Pickering

Our Emerging Universe, by Allan Broms. *Doubleday & Co., $4.95; 296 pp., illus.* Radio Astronomy, by F. Graham Smith. *Pelican Books, $1.65; 265 pp.* Rival Theories of Cosmology, by H. Bondi, W. B. Bonnor, R. A. Lyttleton, G. J. Whitrow. *Oxford Univ. Press, $2.25; 64 pp.* Space Nomads, by Lincoln and Jean LaPaz. *Holiday House, $3.95; 187 pp., illus.* Changing Views of the Universe, by Colin A. Ronan. *The Macmillan Co., $3.95; 206 pp.* The Fabric of the Heavens, by Stephen Toulmin and June Goodfield. *Harper & Bros., $5.00; 285 pp., illus.* The Inspiration of Science, by Sir George Thomson. *Oxford Univ. Press, $4.00; 150 pp., illus.*

On December 27, 1961, Dr. Glenn T. Seaborg, chairman of the Atomic Energy Commission, spoke at a meeting of the American Association for the Advancement of Science in Denver, Colorado. He said that a "democratic-scientific society" has emerged in the United States in the last twenty years, a society whose potentialities are still little-recognized. Science is as much a part of the humanities as are literature and the arts, and the barrier that stands between their complete equality and acceptance is superficial and easily broken down. One of the components of this barrier is a lack of general understanding of the purposes and accomplishments of science. He said that remedies for this weakness include more and better science teaching in the lower schools and at the college level, greater efforts to give the general and concerned public an appreciation of science, and a willingness on the part of scientists to explain their work in popular terms.

It is evident that more and more scientists *do* wish to give their special knowledge to more and more people, and a literature of the interpretation of science is growing rapidly. This is particularly true of astronomy. Many of the books intended for general use have been written by men who, although sometimes not the original researchers, have developed the art of translating the esoteric terms of that research into language intelligible to those who have not learned the language of science.

Our Emerging Universe, by Allan Broms, tells of the birth and ultimate fate of the earth, as far as either of these events can be deduced from our present position—which is probably somewhere about halfway between. The author has documented all his statements carefully in an excellent and, at times, exciting style. Obviously, the story of the earth must include—or, better, be included in—the story of the solar system and the universe and, as a result, certain portions must of necessity be speculative, but Mr. Broms has handled the material better than many who have attempted the task before him. Here and there, however, the reasoning seems a bit difficult to follow. Early in the book, for instance, Mr. Broms says, "Elliptical galaxies would then be spirals after collision and removal of the gas-dust clouds." But elliptical galaxies, which have no arm structure, are apparently free from dust and, therefore, have none to be removed. Spiral galaxies, with arm structure, show evidence of copious dust.

His book is also marred by errors in proofreading, but fortunately none affect essential facts, although captions on Plates XII and XIII are interchanged.

A new method of exploring our neighborhood in the cosmos—a method that began only thirty years ago and that has already added new dimensions to our previous picture—is examined in *Radio Astronomy*, by F. Graham Smith.

Radio astronomy uses the same forces that man has always used, but it enlarges the scope of exploration. Light is visible radiation; radio radiation reaches us in waves of greater length than those producing light and gives us details that cannot be perceived by light.

There are tremendous disturbances in space—impulses from cosmic explosions that occurred perhaps hundreds of thousands of years ago. Some of these cataclysms have left visible traces in clouds of gas and dust. The conception of the nature of these clouds as debris from exploded stars has been confirmed by radio astronomy. Radiations of incredible force, produced in galaxies some-

Mr. Pickering is with The American Museum-Hayden Planetarium as an Assistant Astronomer, and is author of *Captives of the Sun*, which was a recent publication of Dodd, Mead Co.

imes at the limits of visible observation, each us millions of years later. These vere thought to be galaxies in collision nd are so described in this book. Within he last few weeks, however, some doubt ias been cast upon this explanation. The listances between galaxies has been ound to be much greater than was supposed a few years ago, and the nature of he radiation received is believed to be ar greater than that which could be generated by galactic collision. The newest theory pictures a chain reaction of exploding stars, or novae, of the same nature as those formed by the clouds of lust and gas mentioned above. Such a hain reaction would produce radiation such as is registered on radio telescopes.

Thanks to the added dimension of adio astronomy, objects whose forms and outlines have become familiar to us hrough years of observation and photography, now assume new and strange shapes. The accomplishments of radio astronomy will soon equal and perhaps surpass those of optical astronomy.

The details of this field of exploration, its discoveries and implications, together with the problems that confront radio astronomers, are here reported in this clear and understandable paperback book. For the sake of correction, it should be mentioned that the surface gravity of the moon is given as 1/27 that of gravity on the earth's surface. The fraction is 1/6. Mr. Smith obviously knows this, because other relationships depending upon it are correctly stated.

SOME of the most sizable ideas in astronomy are contained in a small book, *Rival Theories of Cosmology*, by H. Bondi, W. B. Bonnor, R. A. Lyttleton, and G. J. Whitrow. The essential differences between two schools of thought are presented here. One holds that the universe is expanding because of a cosmic explosion that took place eight or nine billion years ago. The other believes that the evident expansion is inherent in the cosmos and has always been a part of it; that the universe is now as it always has been and always will be; that the great gaps that might result from a constantly expanding universe are filled by matter (the average distribution of which is constant) constantly created and formed into stars and galaxies.

The book is a presentation of papers originally heard on "The Third Programme," broadcast over the British Broadcasting Corporation's radio facilities in the spring of 1959. The reading of the papers was followed by an informal discussion—which became more than a little lively—of various points made by the astronomers involved. In these sixty pages is a search for the absolute, and it demonstrates man's ability to include a vast amount of space in his thoughts. Reading it is chastening.

In quite another key is *Space Nomads*, · Lincoln and Jean LaPaz. There are ıany exciting factors inherent in the ıbject with which it deals—meteors—d this gives it a powerful advantage. eteorites are meteors that have ar-/ed, and are the only tangible objects at did not have an earthly origin. The rival of a meteorite is an event loaded ith possibilities. We live on a target. ıe shield of our atmosphere saves us om all but the largest meteorites, but ere is no guarantee that a celestial ockbuster might not strike Times ıuare at any time.

The book begins with a detailed de-ription of two recent major meteorite lls, both in Siberia, and of the research ıdertaken to study the results. Other lls dating from prehistoric to recent mes are also recorded. Meteor craters, e scars of these impacts, are described ıd located, and several dubious ex-nples are set aside until further inves-gation admits or rejects them. The ıpression this reader gained from the ook is that it is the result of careful ıd conservative research.

The description of meteorites is com-lete and detailed, as is the account of ıe possible sources and the appearance f meteors. The history of man's attitude ıward stones that fall from the sky is ıscinating, and the final chapter is mazing. A hint of its subject matter ıay impel many to read it. The authors peculate that perhaps some day we will end out space craft to collect meteorites) augment diminishing terrestrial sup-lies of the nickel and iron of which they re composed. Perhaps our space ships hemselves will be great meteorites, hol-owed out and equipped for travel.

WHAT is true of astronomy is perhaps true of every science: it is a great igsaw puzzle with intricately matched ieces that must be interlocked before he large picture can be seen. *Changing Views of the Universe*, by Colin A. Ronan, attempts just that—piecing to-gether what is known of astronomy. In its pages are the early stages of solving he puzzle, when there were lapses of housands of years between the fitting ogether of the pieces and when pieces with a similarity of outline were forced ogether, only to be separated later and efitted. As we draw closer to the pres-ent, more and more pieces are apparent-ly placed correctly in less and less time, and although the picture is building rapidly, perhaps only one tiny corner is completed. It is possible that we are still cheating a little—forcing pieces to fit when they do not really belong to-gether—but the pace of the over-all ap-proach to the completion of the puzzle has accelerated amazingly.

Colin Ronan, with skillful economy of style, tells the story of astronomical re-

search, largely in terms of the men who made each new, great stride and of the instruments they used. This is a fascinating book, but it should be noted that some familiarity with astronomy will contribute greatly to the enjoyment and value to the reader.

The Fabric of the Heavens, by Stephen Toulmin and June Goodfield, follows this same pattern, but in greater and perhaps even better detail. This is another account of man's groping for the truth. Here is the human race, often fumbling, knocking over what it has built, starting again with a slightly surer touch. With experience comes skill. Here are the beginnings of ideas, and of the practical use of knowledge.

The Babylonians, 3,000 years ago, watched, counted, measured, and produced a table of planet motions and positions that is startlingly like our modern ephemerides. The Greeks, inheriting the Babylonian and Egyptian knowledge and tradition, gave the structure of astronomy a firmer foundation and discovered several of the side products of astronomy, such as trigonometry, and speculation gave way to reason. This book brings home the tremendous lapse of years that passed between advances in early astronomy, the slow progress of the science, the loss of knowledge by a people, and the recovery of that knowledge when works of one of their own writers of a bygone age were retranslated from another tongue.

The story of the emergence of astronomy, of its struggles in the dark, and of the astounding accomplishments of early astronomers whose only telescopes were their eyes; the occasional tremendous forward leaps, such as the discovery of the telescope and the understanding of the great physical laws, give this book moments of high drama that stand out as peaks on a remarkably high plateau.

The book ends with Newton and the implications of his discoveries. The authors say ". . . we have watched men studying the universe, as it were, through an intellectual microscope. Where, to begin with, they could make out only blurred outlines in ambiguous proportions, now their picture is crisp and sharp. This change has been accomplished not just as a result of honest observation and reporting. Of equal importance has been the progressive reshaping and refocusing of . . . ideas that form our intellectual instruments."

Every chapter in this book ends with a generous list of reading references, and the book is further distinguished by an excellent index.

The Inspiration of Science, by Sir George Paget Thomson, is a story of dedication, concentration, and perspiration—the three essential ingredients of genius. Sir George, who in 1937 shared the Nobel Prize for physics with C. J. Davisson for simultaneous independent discovery of diffraction phenomena in the electron, is eminently well qualified to write on his subject. He tells of surmounting many of the seemingly impassable barriers to knowledge by pure reason and, chiefly, by imagination. How does one go about dissecting the atom, measuring its component parts, weighing and manipulating these particles, which are so small there is not even a way to describe them?

Several examples of the meshing and interweaving of ostensibly different problems form connecting links to this chronicle, which is further bound together by brief biographies of the various men whose work is used to illustrate the central theme of this volume.

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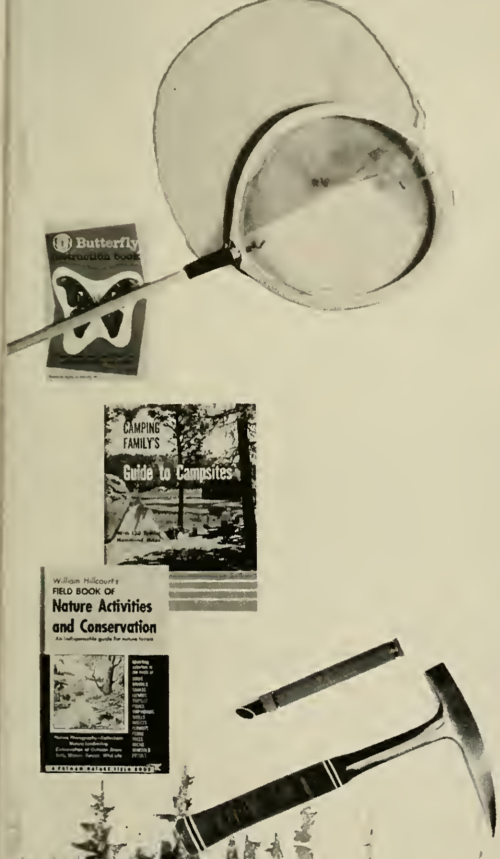

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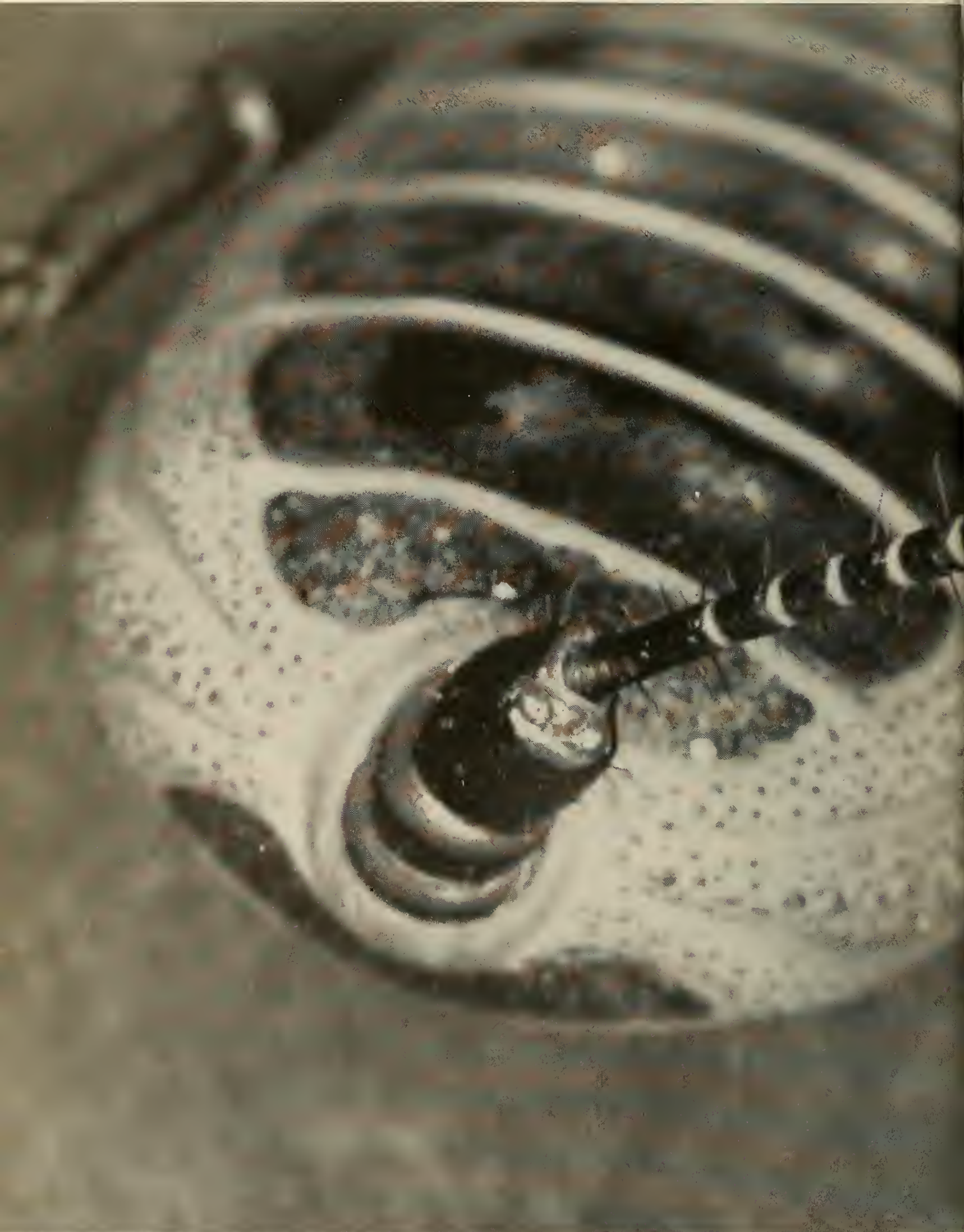


POSTABDOMINAL KNOB at the rear of a whip scorpion bears two gland openings from which acid is sprayed. Animal's aim is not impaired by loss of "whip."

SCORPION studied was *Mastigoproctus giganteus*, which adapts to captivity.

Survival By Acid Defense

Whip scorpion repels enemies with spray

By THOMAS EISNER

"AN INTERESTING STORY was told me . . . at the Biological Society of Washington by General T. E. Wilcox, to the effect that in 1877 at Camp Supply, Indian Territory, a blacksmith crushed a *vinegarone* on his upper left breast. Blisters resulted which extended over the whole breast, and the glands were involved to some extent. He stayed away from work . . . and General Wilcox, who at the time was a surgeon in the Army, treated him."

This excerpt, by one of the leading entomologists of the time, appeared as part of a short note in a biological periodical about forty years ago. The animal concerned, the vinegarone—or vinegaroon as it is sometimes also called—is a remarkable creature. Its name stems from the vinegar-like, acid fluid it ejects when disturbed, and which must have been the cause of General Wilcox's patient's blisters.

Among biologists, vinegaroons are known as whip scorpions. They should not be confused with the true sting-bearing scorpions, although the two are related closely enough to merit joint inclusion in the Arachnida, a group that also encompasses such familiar creatures as the spiders. Whip scorpions are among the most primitive arachnids known. From fossil evidence it is clear that they have survived for almost 300 million years in essentially unmodified form. There are relatively few species of whip scorpions in the world today, but they are distributed through much of the tropics, and in a few places, including North America, extend into the subtropics.

In the summer of 1959, I spent several weeks at the Southwestern Research Station of the American Museum of Natural History in the Chiricahua Mountains of Arizona, a region that is as beautiful as it is interesting to biologists. It was there, on the first evening at the station, that I was introduced to whip scorpions. We went out at night, properly equipped with head lamps, intending to observe

Grasshopper mouse, a voracious desert rodent, halts its advance on the scorpion, which has directed its spray at attacker's muzzle in this laboratory encounter. The whip action of arthropod's flagellum has caused the tip to blur.

the vast array of insects, spiders, millipedes, and other arthropods that forage out in the darkness. "Here, let me show you something," my companion said suddenly, and as I knelt down for a close look at my first live vinegaroon, he gave the animal a quick, calculated tap—and I got sprayed.

Whip scorpions do very well in captivity, and during the past two years Dr. Ralph Ghent and I have had an opportunity to study them in our laboratory at Cornell. One of the things that first struck us as peculiar when we collected whip scorpions in Arizona, was that whenever one of them was picked up by hand, the spray would invariably hit the fingers with which the animal had been grasped. It did not matter whether a front or a rear appendage was seized: the fingers always bore the full impact of the spray. Evidently, vinegaroons do not discharge their spray in a fixed direction, but actually aim it toward that portion of their bodies under assault.

A technique was developed by which this remarkable marksmanship could be visualized more precisely. Individual whip scorpions—glued to rods so as to prevent them from walking about—were placed on sheets of filter paper soaked in a dark red solution of an indicator dye (phenolphthalein). When the animals spray on this paper, the acid secretion discolors the dye, and a neat pattern of small white dots is produced, outlining the direction, range, and dispersion of the defensive discharge.

In order to understand exactly how the animals aim, we must first know something about the glands. There are two of them, disposed side by side in the opisthosoma (the posterior, legless abdominal portion). Each gland is a relatively voluminous sac in which the secretion is stored, and the thin walls of which are the glandular tissue that synthesizes the secretion. The sac is enveloped by a sheet of compressor muscles, which by contraction effect the discharge. Posteriorly the glands taper and converge, eventually leading to the outside by way of two narrow, parallel ducts that open at the end of the short, three-segmented postabdominal knob, which forms the stalk of the flagellum or "whip." The slitlike orifice of each duct is kept closed by a special valve; at the time of discharge the valve is forced open by appropriate muscles.

In aiming the spray, the whip scorpion uses its postabdominal knob as a revolvable "gun emplacement." No sooner is the stimulus applied than the animal rotates the knob in such a way that its tip, bearing the glandular openings, is brought to point precisely toward the source of irritation. The knob can turn to the right or to the left with equal facility. It is somewhat limited in bending up and forward, but when the animal is discharging anteriorly, say to the head region or to some of the front appendages, it compensates for its inability by adjusting the opisthosoma as a whole, revolving it at its base and bending it upward.

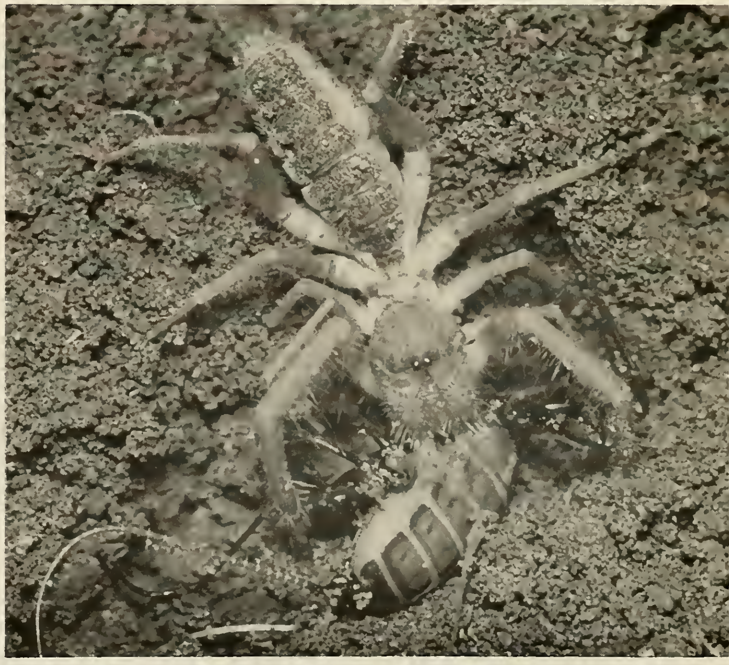
While aiming, the flagellum accompanies the movements of the postabdominal knob in such a way that just before discharge it is usually pointed toward or even brought in contact with whatever instrument is used for stimulation. Is the animal getting its bearings on the target by using the flagellum as a "feeler"? Evidently not, since total amputation of the flagellum in no way impairs the accuracy with which a discharge is aimed. In taking aim, the animal apparently relies on no other sensory information

IN FRANTIC ATTEMPT to cleanse itself of the acid spray, the fleeing mouse paws its muzzle with front feet and plows into sand. Reaction wore off after about half a minute and mouse returned to attack, but was repelled several times.

than the trauma, however mild, stemming from the area stimulated. We have never had a whip scorpion spray in response to any but direct contact stimuli. A sudden movement or strong tapping fails to elicit a discharge.

Since the glandular reservoirs are of considerable capacity, a whip scorpion can discharge many times in succession. More than ten discharges are the rule, although we have seen as many as nineteen. Equally prodigious is the rapidity with which the secretion is restored. Three individuals that were caused to exhaust their supply were again able to spray two, three, and four times respectively less than a day later. The secretion is ejected with considerable force, and a range of over two feet is not unusual.

How effective is the spray in defense against predators? Judging from what it did to us, there was no question that its repellent potential was substantial. Although we proved to be far less sensitive than General Wilcox's blacksmith, and actually never developed blisters following the several hundred sprayings we must have received while handling our captive vinegaroons, the spray showed itself to be extremely painful to the exposed surfaces of the



SOLPUGID devours immature scorpion after catching it on its back. Unable to aim its spray properly from such a position, it could not repel attacker.

Saclike glands, which store the acid, converge on ducts in postabdominal knob, shown in dissected ventral view of opisthosoma, or legless posterior.

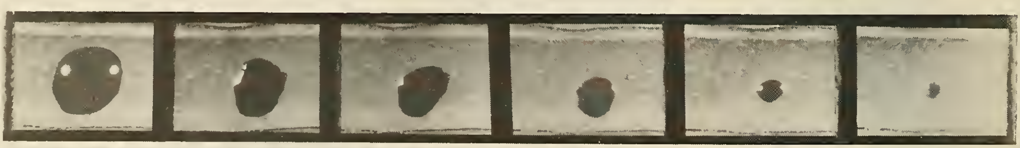
face, and especially to the eyes. We soon learned never to pick up a vinegaroon unless we held it out at a safe range. But vinegaroons must cope with predators other than man. How do whip scorpions live, and what real enemies do they have?

As a rule, whip scorpions are active only at night. They forage about at ground level in search of animal prey, but we know relatively little about the exact nature of their diet. Judging from their habits in captivity, they may primarily eat insects and other arthropods. The prey is caught with the front appendages (pedipalps), and is promptly crushed in an overpowering embrace. Only the liquids are extracted from the prey; skeletal and other solid parts are discarded. During the daytime, whip scorpions go into hiding. One finds them commonly in clefts among rocks, but in areas where natural shelters are scarce, they dig burrows of their own. They are quite adept at digging, and we have frequently watched them build their shelters in laboratory cages filled with damp sand. They burrow with the pedipalps, the claw-bearing tips of which serve as effective carving devices. Once a small pile of soil has been pried loose, it is embraced and lifted by the pedipalps and carried off a few inches to the side. It may take dozens of sand loads over a period of several hours to complete an adequate burrow, but once finished, it may serve the whip scorpion for days or even weeks. By studying marked individuals in the field, we were able to determine that they return to the same shelter day after day. Their foraging territories are hence likely to be quite fixed.

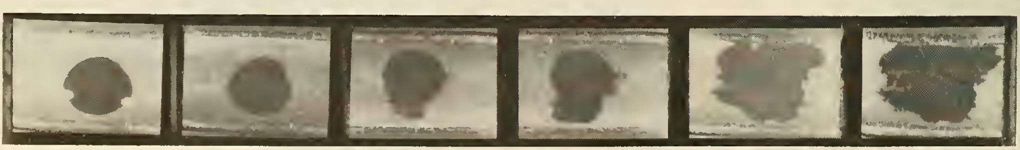
Obviously, in the tropical and subtropical environments they inhabit, whip scorpions must be exposed to a truly formidable array of predators—not just while they are actively foraging, but also while they remain in their shelters. Ants alone, by the sheer weight of their numbers, must be a constant hazard. But other insects and arachnids are potential enemies, as are many amphibians, reptiles, mammals, and, to a lesser extent, birds.

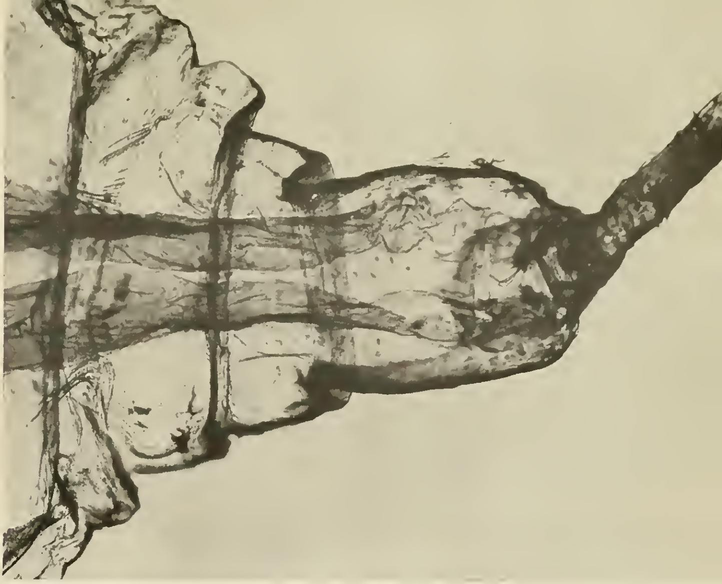
We have actually never had the luck of seeing a whip scorpion defend itself against attack in nature. But in the laboratory, dozens of encounters were witnessed, involving a whole assortment of predators. The following descriptions of some of these encounters bear testimony to the extraordinary effectiveness of the spray.

Individual, small whip scorpions were released together with a dozen or more ants *(Formica exsectoides* Forel) into small enameled pans, coated along the sides with petrolatum to prevent escape and lined with phenolphthalein-impregnated filter paper. In their artificial environment, the ants were initially reluctant to attack, and despite repeated casual encounters never grasped the whip scorpion with their mandibles. When prodded with a brush, however, the ants became considerably more agitated and aggressive, and on several occasions were



Drop of acetic acid, one of the two ingredients in the whip scorpion's spray, does not penetrate cockroach's body wall, *above*, but instead it evaporates. Drop, *below*, with 5 per cent caprylic acid added to it, spreads and penetrates.





Gland ducts, made transparent with chemicals, are seen running parallel along three-segmented postabdominal knob and terminating at two openings.

induced to attack. In each case the response was the same: when grasped by an appendage, the whip scorpion instantly revolved its postabdomen and sprayed with accuracy toward the assailant. The ant was promptly repelled and fled rapidly and aimlessly, sometimes leaving on the indicator paper a discolored trail of the residual secretion left on its body. Periodically during its retreat, the ant would show intense cleansing activity, proceeding slowly and dragging its body and mouthparts against the substrate. Recovery was eventually always complete, although an ant never resumed an attack for several minutes after being sprayed. Under normal conditions, a whip scorpion would take advantage of this delay by making an unmolested escape.

For a short time after each discharge no new ants ever ventured within the immediate vicinity of a whip scorpion, apparently because of the repellent action of residual secretion remaining on the whip scorpion's body. This, too, must be helpful to a whip scorpion, particularly when ants, which are likely to attack in swarms rather than singly (for example, army ants), are involved.

Another dramatic spectacle occurred when we offered whip scorpions to captive grasshopper mice. These desert-dwelling rodents are highly aggressive and voracious, and will fearlessly pursue their arthropod prey. The moment a whip scorpion was introduced into a cage, the mouse pounced upon it, but on contact was instantly repelled by an accurately directed discharge. The mouse jumped back and scurried about frantically, pausing occasionally to "paw" its muzzle with its front feet, or to dig and bury itself into the sand, plowing along and leaving a deep trench. When the reaction subsided, after about half a minute, the mouse always attempted to attack again, only to be repelled by another discharge. As long as the whip scorpion had not exhausted its secretion, it proved invulnerable. Only after it could no longer spray, would it finally be overcome and eaten.

These are just two of the many predators tested. The spray was equally effective against others, including lizards, birds, an armadillo, and solpugids. The latter are an interesting type of arachnid, found in Arizona in the same locality as whip scorpions, and quite probably one of their important natural enemies.

Solpugids are pugnacious creatures, and usually attack at once any small insect or other arthropod offered them, crushing it and chewing it to a pulp with huge pincer-like mouthparts. Larger prey are also overcome without much of a struggle and are incapacitated promptly by the initial wound inflicted. Whip scorpions, however, always managed to repel solpugids with their spray before they received any kind of injury. In only one exceptional instance was a whip scorpion eaten. This individual also sprayed but when it was first dropped into the cage, it landed on its back. From this abnormal position it might not have aimed properly, instead shooting its spray into the soil.

There remained no doubt about the spray's effectiveness. It was also clear that a major asset is the ability to aim the spray in different directions. In the absence of such marksmanship, predators such as ants, predaceous beetles, ground-foraging spiders, centipedes, and all such other enemies that may offer no more than a small target surface, are likely to receive only an

Permeability of cuticle can be seen in white band on dorsal skeletal shell of insect to which acid was applied.

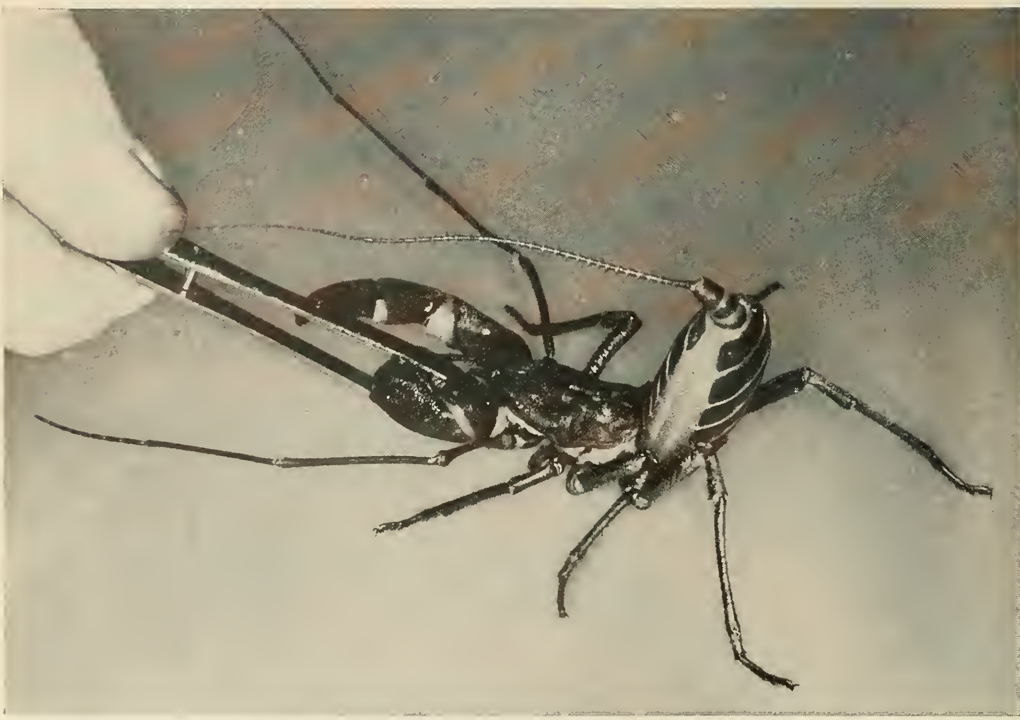
insufficient dose of spray. But aiming must be of advantage also where larger predators, such as vertebrates, are involved, since these usually approach their intended victims headfirst, and when they attack are hence likely to bear the full impact of an aimed discharge where they are most vulnerable—in the eyes.

What became perhaps the most interesting side line of this study emerged as a result of the identification of the chemical constituents of the secretion. We suspected from the outset that one of the ingredients was acetic acid, since this acid—the active constituent of vinegar—has an odor that is virtually unmistakable. It is noteworthy, in this connection, that the common names by which vinegaroons are known elsewhere in the New World, also pay tribute to the vinegar-like odor of the spray: in Martinique they are known as vinaigriers, in Brazil as *escorpiões vinagre*, and in Mexico they are called *vinagrillos*.

The precise identification of the secretion became the concern of two colleagues at the Chemistry Department of Cornell, Professor Jerrold Meinwald and Dr. Alastair Monro. About one dozen whip scorpions were milked, simply by placing small glass vials over their postabdominal knobs while simultaneously pinching them and causing them to spray. After subjecting the samples thus collected to a series of more or less elaborate analytical procedures, the chemists came up with the answer: acetic acid, in the remarkably high concentration of 84 per cent. The remainder was largely water (11 per cent), plus a small amount (5 per cent) of yet another organic acid, caprylic acid.

Acetic acid, a powerful irritant, would appear to be of sufficient toxicity to account for the repellency of the mixture as a whole. One might therefore be inclined to dismiss the caprylic acid as insignificant, if for no other reason than its low concentration. This, however, would be a mistake. Without caprylic acid, the secretion would not be nearly so effective against insects and other arthropods. To understand exactly what caprylic acid does to improve the mixture we must first digress a bit.

Insects, spiders, scorpions, and centipedes, together with the rest of the terrestrial arthropods, all share one thing in common: they live on land and are thus subject to desiccation. All terrestrial creatures, plants and animals alike, have evolved means by which water loss from their bodies is minimized. In arthropods, the outer shell, or cuticle, in addition to its obvious skeletal function, acts as an important barrier to desiccation. Arthropod cuticle is not simple in structure, but for present purposes it will suffice to regard it as being made up of two principal layers: an inner thick layer, the procuticle, consisting of a solid matrix of complex molecular configuration that gives skeletal rigidity to the cuticle; and an extremely thin outer layer, the epicuticle, the most important feature of which is its rich wax content. The waxy epicuticle is largely responsible for rendering the cuticle water impermeable. Without it, the arthropod would quickly dry up, since the procuticle, despite its thick-



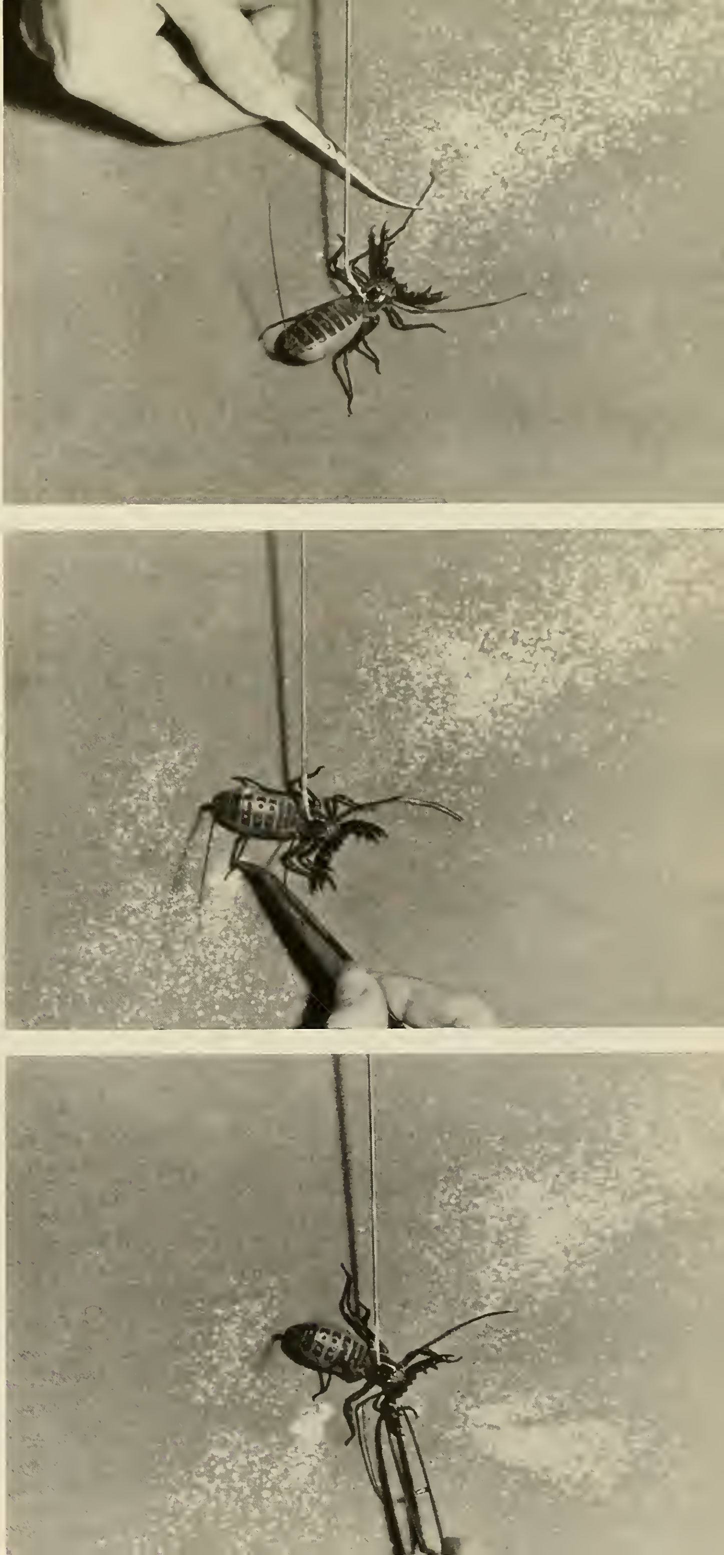
Flexibility of the whip scorpion is demonstrated in this experiment, which shows response to stimulation of anterior appendage (pedipalp) by sharp inclination of opisthosoma. Secretion ejects forward, as "whip" touches the irritant.

Dr. Eisner is Assistant Professor of Biology, Cornell University. In line with insect physiology studies he has observed whip scorpions under laboratory conditions for two years.

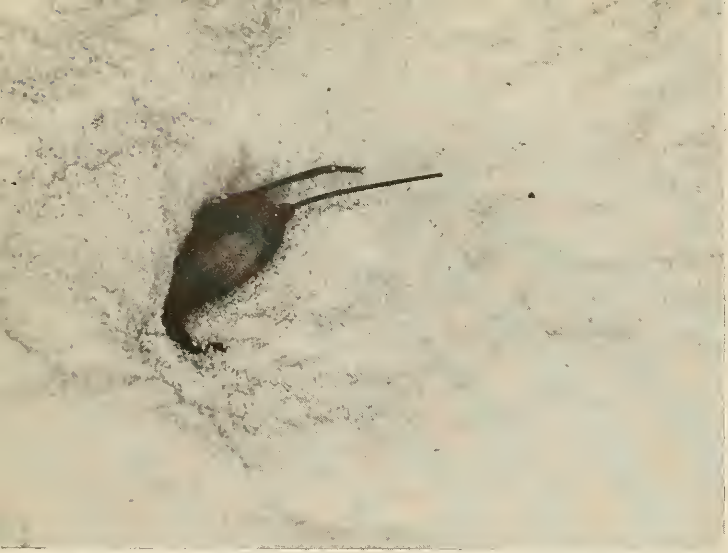
ness, offers relatively little resistance to the passage of water.

This takes us back to the whip scorpion's spray. How does the secretion penetrate the cuticle of arthropod enemies? Offhand, one might reason that arthropod cuticle, by virtue of its waxy covering, should be highly impermeable to the secretion, particularly since acetic acid, its major ingredient, is virtually wax insoluble. In actuality, however, the secretion proved instantly repellent to arthropods such as ants and solpugids and must evidently have penetrated their cuticle quite readily. The paradox is resolved by the presence of caprylic acid. This acid, unlike its partner, is a good wax solvent, and its presence in the secretion enables it to disrupt the epicuticular barrier, thus priming the way for the penetration of the acetic acid (the procuticle, being water permeable, offers only negligible resistance to the penetration of acetic acid). The preceding is not conjecture. It has been borne out experimentally.

Two types of tests were made. The first of these involved straightforward permeability measurements of isolated pieces of cuticle. The technique consisted of mounting a piece of cuticle on a layer of gelatin impregnated with an indicator dye, and then applying to the surface of the cuticle a mixture of the same chemical composition as the secretion. Its penetration rate through the cuticle was then compared with that of a control solution containing acetic acid and water, but no caprylic acid. Invariably, the mixture of the composition of the secretion would be the first to effect a color change in the indicator-laden layer of gelatin. Evidently, caprylic acid has a hastening effect on the penetration rate. With this technique it was also possible to show that it is the epicuticle and not the procuticle that acts as the main



While glued to wire to restrain its movement, a scorpion discharges three consecutive sprays in the direction of stimulated appendages. Accuracy of aim is indicated by spray pattern on phenolphthalein-treated filter paper.



Emerging "whip-end" first from sand tunnel, scorpion works to complete a burrow. Claw-bearing pedipalps, useful as carving devices, embrace a load of damp sand, *above*, as animal backs out of hole. Burden is then deposited on

barrier to acetic acid penetration. All one had to do to render the cuticle permeable to acetic acid was to scratch its surface gently with a mild abrasive powder. From this it may be inferred that caprylic acid exerts its penetration-promoting role by chemical disruption of the waxy epicuticle.

A second series of tests was made with live instead of dead cuticle preparations. When acids or similar irritants are applied topically to an insect, they usually induce prompt cleansing reflexes. These reflexes are more or less delayed, as they depend on the penetrability of the irritant through the cuticle to the sensitive tissues beneath. It follows that one can obtain a rather neat measure of the irritant effectiveness of a sample simply by timing the delay between application and the cleansing reflex: the earlier the onset of the reflex, the more effective the sample. The test animals were cockroaches, which are ideal for the purpose. When droplets of acid are applied to a leg, for instance, the roach brings that particular leg forward and licks it with the mouthparts. When application is to the body surface, it uses the nearest leg to scratch the affected region. Intact roaches are difficult to work with since they do not remain still, but this is remedied by decapitating them, an operation that brings their locomotory activity to a halt without hindering their reflex responses. By basing our studies on reflexes of this sort, it was shown conclusively that a mixture with 5 per cent caprylic acid is a much more effective irritant than one that contains acetic acid alone.

In the course of these studies we discovered yet another function of caprylic acid: it acts as a wetting agent that promotes the spread of the individual spray droplets over the cuticle of the enemy, thereby markedly increasing the effective area of contact of the poison. When acetic acid alone is applied to cuticle, the droplet remains globular and shrinks away until evaporated. By contrast, a comparable droplet with 5 per cent caprylic acid spreads broadly.

There is one question that unfortunately still remains unanswered for lack of data: what are the reasons for the whip scorpion's apparent insensitivity to its own spray? Whenever a whip scorpion discharges at an enemy, it invariably gets an incidental bath of its own, but this never seems to affect it in any way whatever. We once literally drenched a whip scorpion in a solution of the same composition as its secretion, and that whip scorpion is still alive in our laboratory today. Perhaps tolerance to the acids is simply because of an especially impermeable integument, but this remains to be proved. The glands themselves must be remarkable structures to be able to manufacture and store acetic acid in the fantastically toxic concentration of 84 per cent. We are currently working on a great many other species that also have chemical defenses. There is an ant, for instance, that secretes a mixture rich in citronellal, one of the oldest known insect repellents ("citronella candles" are still commonly used to repel mosquitoes). There are even certain millipedes that secrete hydrogen cyanide, a most poisonous molecule, and one which—under its more familiar name of prussic acid—has achieved notoriety in the annals of human crime.

In its special refinements, the spray of the vinegaroon bears striking resemblance to commercial insecticidal sprays. These sprays also commonly contain additives designed to increase both the spreadability of droplets and the penetrability of poison. But by aiming its spray directly at the enemy and thereby minimizing the expenditure of secretion, the whip scorpion actually surpasses—in at least one major way—the usual effectiveness with which man can dispense his own insecticidal formulations. In agricultural spray programs, it is found too often that the countryside must virtually be drenched in poison to control specific pests. To demand that man do his job with the same effectiveness as vinegaroons may be asking too much. Vinegaroons, after all, have had target practice for 300 million years.

pile with previous loads, *right*, a few inches from burrow entrance. Scorpion usually is found living in clefts of rocks, but will spend hours digging a shelter in area where soil is friable, later using it as a base for foraging.

WHIP SCORPION feeds on a cockroach, the abdomen of which is visible within the encircling pedipalps. Only liquids are extracted from the prey, while the skeletal and other solid parts are discarded. Scorpion hunts food at night.

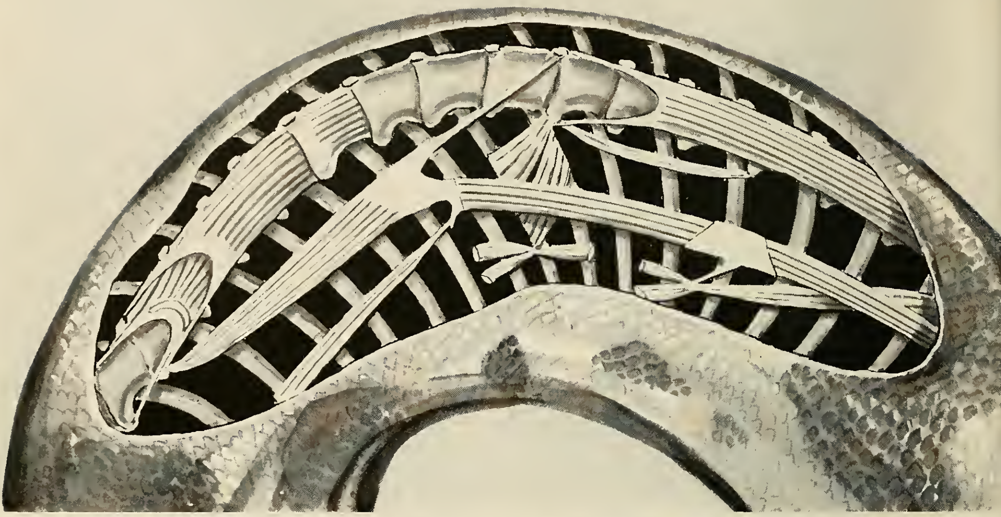
The Six Giants

Two boas and four pythons of the tropics are longest of all existing land animals

By Clifford H. Pope   Drawings by Matthew Kalmenoff

Zoogeography, the study of distribution of animals, is a venerable branch of biology. Within this field, the central problem concerning the distribution of land animals is to explain how related species happen to be abundant on all continents, in spite of seemingly impassable ocean barriers. Since the dispersal of these animals took place in ages gone by, we must resort to theories. The most plausible one holds that the continents have long been separated by oceans much as they are today. This means that, as opportunity afforded, these animals must have crossed straits and short, narrow land connections between islands and continents.

Many minor changes in land configuration have taken place in com-



Portion of structure of *Boa* musculature is a series of muscle columns, top right, which overlap, top left, and from each of which branch retractor muscles. This pattern repeats at every vertebra, building up in complex layers.

paratively recent ages. For example, geologists have shown that, in Eocene times (about fifty million years ago), Sumatra, Java, and Borneo formed part of the Sunda Shelf which, in turn, was part of the mainland of Asia. When the Sunda Shelf was broken up, countless species of animals became isolated on one resulting island or another. Similarly, the isthmus now joining North and South America has not always existed: when it submerged, the animals of these two continents could not move freely from one to the other. Many additional cases could be cited, but these two are specially pertinent for the living reptiles and. in particular, the giant snakes with which we are concerned here.

As climates, in turn, are no more permanent than some islands, migration across land masses—for example, from Asia to Europe, or vice versa—has been possible for reptiles during those geologic times when tropical temperatures prevailed throughout the northern latitudes.

Although water barriers seriously interfere with dispersal, land animals often manage to cross wide stretches of water in one of three ways: in currents of air, on floating rafts of vegetation, and through the aid of other animals. including man. Everyone has heard of storm winds carrying objects great distances. Insects, spiders, and mites are commonly dispersed in this way. It is little wonder that all islands capable of supporting animal life are inhabited by insects. The surprising fact is that the ability to fly has little to do with the dispersal of light creatures; the less they use their own strength, the better the chances for dispersal. There is a whole literature on "rains of frogs," and all alleged cases cannot be laughed off. Frogs would be the first of the higher animals to be lifted by a cyclone, because they so often live in shallow water.

For reptiles, dispersal by floating vegetation is most important. The records are replete with examples of animals floating across wide stretches of sea on masses of matted vegetation. These masses sometimes even bear erect trees of good size. Animals such as the giant snakes possess both arboreal and aquatic tendencies, as well as the ability to live for months without food or water, so they would be logical candidates for raft transportation. But although a snake might live well enough on such a raft, which may be a bit of its original home, it could perish on a barren beach before reaching suitable terrain.

The most famous raft report involving a giant snake is that made by Alfred Russel Wallace: a boa constrictor arrived in good health on St. Vincent, one of the Windward Islands, after floating 200 or more miles from South America. It has also been reliably reported that an Indian python, at least 18 feet long, was carried about the same distance down the Godavari River of India to Kotapalli, an island lying across one of the river's mouths.

As to the effectiveness of water barriers, science has profited greatly from studies made after the stupendous explosion of Krakatoa, the volcanic island in Sunda Strait. Animal life there was destroyed by the eruption in 1883, yet by 1908 the reticulate python was found on the island; some ten years later it was common.

Finally, there is no question that man also has moved and continues to move reptiles—including the giant snakes—in one way or another. The wonder is that these snakes still seem to have reasonably "natural" ranges.

Reptiles apparently moved outward, initially, from the tropics of Africa and Asia, but this does not mean that they have deserted these regions; on the contrary, they are still as abundant there as anywhere. A number of dominant reptile groups have moved from the Old World to the New, whereas it is not certain that any have done the

everse. The place where snakes first riginated is unknown, as are the ourses of their earliest dispersals. Iore recently, they have spread out rom the Old World tropics.

The giant snakes—boas and pythons -belong to an ancient family. Fossils f this family have been found that late from the Eocene epoch. Although he fossil record is all too scanty, it loes show that these snakes were once videly distributed in Europe and temperate North America—regions where hey are now all but absent, presumably because of today's relatively severe climates. Their wide ancient distribution explains their abundance in uch well-separated parts of the world as South America, Africa, tropical Asia, and Australia.

THE six largest living giant snakes —members of the family Boidae— are the anaconda, the boa constrictor, and the Indian, reticulate, amethystine, and African rock pythons. With the exception of the boa constrictor, these form a distinct size group among the snakes of the world.

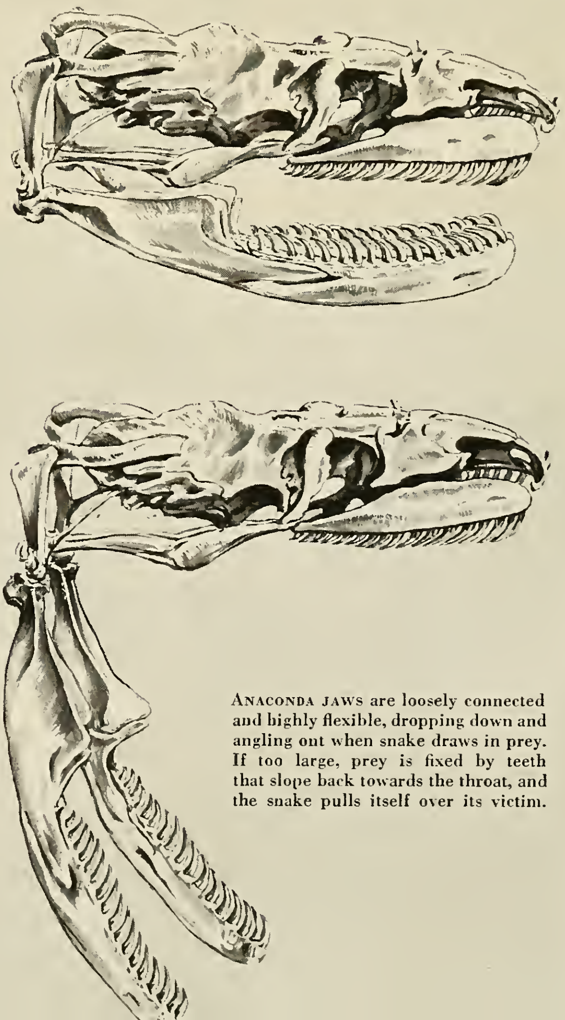
The boa constrictor, with a maximum length of 18.5 feet, is noticeably smaller than the other five. Yet the only other snake that has a maximum length approaching it is the king cobra, which sometimes grows to be a little over 18 feet long. But this highly venomous Asiatic reptile, not a relative of the "big six," is so slender that its weight never approximates that of the boa constrictor.

The following measurements will indicate how wide is the gap between these "longest" and the remaining 2,500 or more living species of snakes. Taking 12 feet as a limit, I find that, the king cobra to one side, only a few other species of boas and pythons and four snakes of other families attain it. Three of the last four do so very rarely. These are the highly dangerous mamba (largest of the four, it has a maximum length of 14 feet and lives in Africa), the bushmaster (a pit viper of tropical America), the dhaman, and the keeled rat snake (both harmless species of southern Asia).

The frequent presence of one or more of the giant six in zoos and circuses is responsible for the belief that all boas and pythons are big snakes. The truth is that only about 15 per cent of the 65 or more species of the family Boidae (including, of course, the six giants) attain the 12-foot limit. No other family of snakes has more than two 12-footers.

Our giants share certain characteristics that set them off from other animals. Indeed, no other group of creatures has a greater array of extraordinary qualities. They are the longest of all existing land animals, as well as the lightest of the big ones. They are characterized by slender, highly flexible bodies that enable them to throw constricting coils about their prey and their enemies. They are the only large vertebrates without useful appendages; their tiny spurs are but remnants of lost hind legs. They are about the only big terrestrial creatures without a vocal apparatus. They are unable to produce a sound above a hiss. Also, having no external ears, they lack sensitivity to airborne sounds. They depend on vision to a limited degree and perceive mainly through organs of smell and, in some cases, heat-sensitive labial pits, and are well adapted to both nocturnal and daylight activity.

THE big snakes, with few exceptions, move (or crawl) more slowly and more silently than do other large terrestrial creatures. No other large terrestrials, however, are as much at home in water as on land. Three factors make the big snakes superior



ANACONDA JAWS are loosely connected and highly flexible, dropping down and angling out when snake draws in prey. If too large, prey is fixed by teeth that slope back towards the throat, and the snake pulls itself over its victim.

in the water: a transparent, watertight eye-covering, an undulatory motion, and an ability to hold the breath for a long time. Only one of the great snakes, the anaconda, takes much advantage of this amphibious ability, but all enter water freely when the occasion arises. They readily climb trees, too, and crawl among branches that will support their weight.

No other large land animals swallow objects approximately as large as themselves or devour whole animals the size of a man. This capacity means that they can take in at one time much more fuel (relative to weight) than can other land animals. Since they are able to consume in one meal as much as four hundred times their daily energy need, their periods of fasting sometimes last well over a year.

The ability of a giant snake to crush a victim by constriction has been exaggerated in the public mind. After seizing its prey in viselike jaws, the serpent coils its body about its opponent and squeezes. The muscular pressure is sufficient to contract the victim's chest and thus halt the ability to breathe. Bone-breaking exertion, therefore, is not at all necessary.

The giants, like other snakes, are "cold-blooded," or, more properly, ectothermic. Except for one that shivers to raise the body temperature when coiled around its incubating eggs, these snakes have no internal heat-producing mechanism. As a result, their temperature remains close to that of their surroundings. Evidently, the Boidae flourish within or close to the tropical regions of the world.

The anaconda and boa constrictor are viviparous, bringing forth their young fully formed, as do most mammals. The pythons lay and brood eggs, but rarely incubate them. The young grow rapidly until they reach sexual maturity, after which the rate of growth continues, but much more slowly. It is next to impossible to judge length of life in the wild, but captive giants have been known to live over twenty years. Traditionally, the Boidae family has been divided into the boas (Boinae) and the pythons (Pythoninae), but recent research suggests that much more must be learned about their anatomy before they can be divided into subfamilies.

Our six giants fall into simple geographical groups: the two boas of the New World and the four pythons of the Old World and the Australian region. This convenient distribution does not apply to all of the Boidae, however. Many smaller species of boas are found in various parts of the Eastern Hemisphere. More detailed discussion of each of the six giants must include a few words about their range and habitats, maximum length, and certain other characteristics.

Boa constrictor: As the most familiar of the six, this giant deserves treatment first. This species illustrates the rare circumstance of an animal with a common name that is also its scientific name. The latter is properly written as above, with an initial capital letter and in italics. The common term "boa constrictor" is often used in a broad sense to mean almost any huge snake, but this extension of meaning is inclined to create ambiguity.

The range of *Boa constrictor* ex-

Range of the reticulate python is in black, indicated by black scoring in areas where it overlaps the Indian or amethystine. Queensland coast is only part of Australia with a large python.

Several species of boas are found in South America, and one ranges as far north as Mexican lowlands. Most are in Orinoco and Amazon basins; some go south to Bolivia and north Argentina.

tends from Argentina to the northern Mexican states of Sonora and Tamaulipas, both close to the United States. Smallest of the six giants, it reaches a maximum length of over 18 feet. It is also the most adaptable of the big snakes. In Mexico it thrives in mild deserts, yet elsewhere it is at home in wet tropical forests, open savanna, and cultivated fields, from sea level to moderate elevations.

Anaconda: The next of our six, the anaconda *(Eunectes murinus)*, of South America, is probably *the* giant among the giants. A 37.5-foot specimen has been reported, and the species is usually greater in girth than any of the other Boidae.

The word "anaconda" is of doubtful origin. Some scholars, tracing it to Ceylon, say it is derived from the Tamil words *anai*, which means "elephant," and *kolra*, which means "killer." On Ceylon the name apparently was applied to the Indian python. Though the word does not appear in early South American literature, it is now universally applied to the New World snake, and not to the Indian python. Other names commonly used for the anaconda in South America are *sucuriú* and water kamudi. There are several different spellings of both of these words.

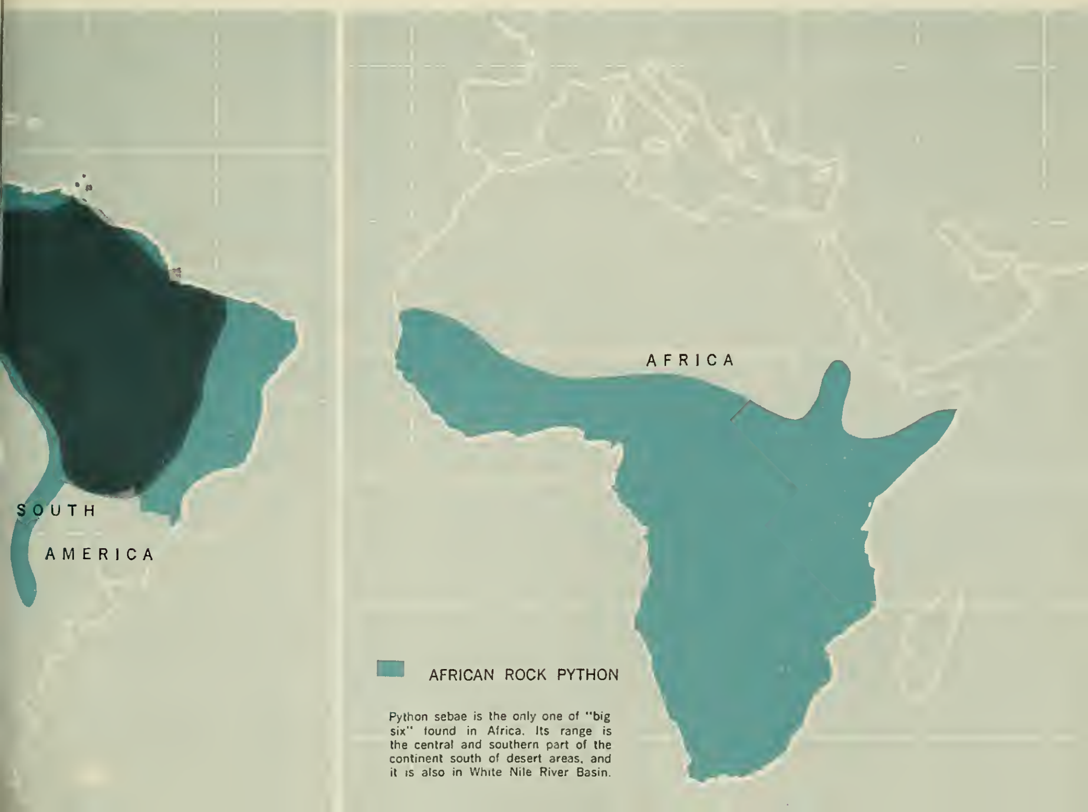
The anaconda is also known as the "water boa." It frequents permanent bodies of water that have enough vegetation in them to afford cover and insure a supply of food. Though a tendency toward aquatic habits is noticeable in the other giants, this is the only one that can be called truly aquatic. I do not mean that the anaconda cannot crawl about on land as well as the other great snakes; it merely prefers to spend most of its time in water and never to stray far from it.

The anaconda has only one small relative in its genus—*Eunectes*. This is *Eunectes notaeus*, which lives in Paraguay and adjacent regions. This snake is, however, too small to be rated among our six giants.

African rock python: Turning to the four Old World giants, all of them pythons, we shall first consider the African rock python *(Python sebae)*. This species, reaching a record length of 32 feet, is often exhibited in zoos. It is the only one of our six with a range that does not overlap that of another. It is widely distributed throughout Africa, except in the great deserts (a need for humidity presumably keeps it out). It prefers savanna country and has been found at high altitudes. All stories of huge African snakes must stem from this lone giant. The few other pythons of Africa are small and have ranges relatively limited in comparison with *P. sebae*.

There can be little doubt that man has been in close association with the African giant longer than with any other. If, as seems probable, man evolved in Africa, he must have "grown up" with the python. Little wonder that python worship reaches its height in Africa, and that this giant has become its symbol.

Indian python: This Old World giant *(Python molurus)* is sometimes called the Indian rock python. It is not only the second most widely known of all the giants, but also is the first species about which a large amount of



Python sebae is the only one of "big six" found in Africa. Its range is the central and southern part of the continent south of desert areas, and it is also in White Nile River Basin.

Mr. Pope, well-known herpetologist, is author of *The Giant Snakes*, which was recently published by Knopf, and from which this piece was excerpted.

scientific information was acquired.

Because it is popular with the snake charmers of India and Pakistan, the Indian python is seen constantly by the people of those countries and by tourists. The zoos of the world stock it regularly, even though it is less spectacular than others. Its greatest known length is about 20 feet.

The Indian python is widely distributed on the mainland of southeastern Asia, including southern China and, to a more limited extent, the East Indies. It frequents jungles as well as regions devoid of forests, and rivals the African rock python in reaching considerably higher elevations.

Reticulate python: This animal *(Python reticulatus)* has been called the largest of the great snakes, but there is a strong tendency now to give honors for size to the anaconda. Its accepted maximum length stands at 33 feet. The reticulate python has always been popular with zoo and circus men because it lives well in captivity and has a striking color pattern.

The range of the reticulate python starts in Burma and extends eastward (south of China) and southeastward to include the Philippine Islands and Timor (just north of Australia). Thus, all the humid tropics of Asia, and the great archipelago to the southeast of it, are inhabited by the Indian or the reticulate python or by both.

Amethystine python: The "dark horse" of the giant snakes is the amethystine python *(Liasis,* or *Python amethystinus).* It was introduced to science as long ago as 1801, still there is much confusion over its proper name, its maximum size, and the extent of its range. Opinions also differ in regard to its relationships, some students putting it in the genus *Python*, others in the genus *Liasis*. This difference of opinion indicates a need for further anatomical studies.

The amethystine python has been known to reach lengths of at least 22 feet. It is distributed from northeastern Australia to the Philippine Islands. It has shown a preference for riverbanks in wild country, but it is also found near human habitations. Few people in the United States ever have seen the species alive, as our zoos seldom exhibit it. Though not a rare snake, it is an elusive one.

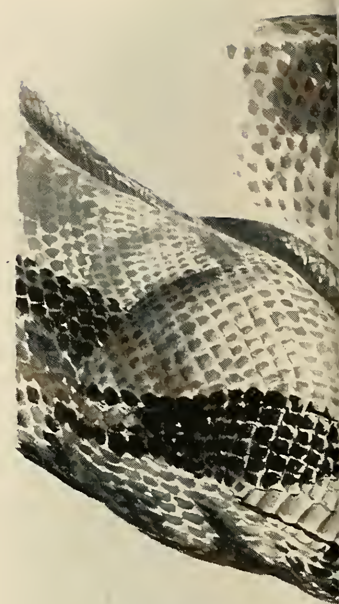
While science encourages an objective view of nature, it has made no startling headway against snake lore, which still persists among all of mankind, both civilized and primitive. Tens of thousands of beliefs have been conjured up about giant snakes, and many of these have crystallized into various forms of serpent worship.

An article published only a little more than twenty years ago (under the authorship of "Tursa") presents a curious mixture of python fact and fancy. A python, it is said, justifiably viewing as an impediment the "antlered head of the stag it has crushed," tears a strip of skin from the victim's back (being careful to leave the strip attached to the head), binds the head to a tree or sapling, and revolves the stag's body until the head, with its horns, is twisted off. The author apparently bases his conviction on the frequent discovery of antlered animal heads "in the neighbourhood of recently fed snakes." Oddly enough, he is even more impressed by irrefutable evidence of a python killing and swallowing an adult leopard, a simple feat compared with the quite fantastic one in which he, along with countless others, obviously believes so firmly.

Tursa writes that the Nepalese, "second to none in jungle lore," say that the python must anchor its tail about a sapling or a leg of its victim before the powers of constriction can be applied with any effectiveness.

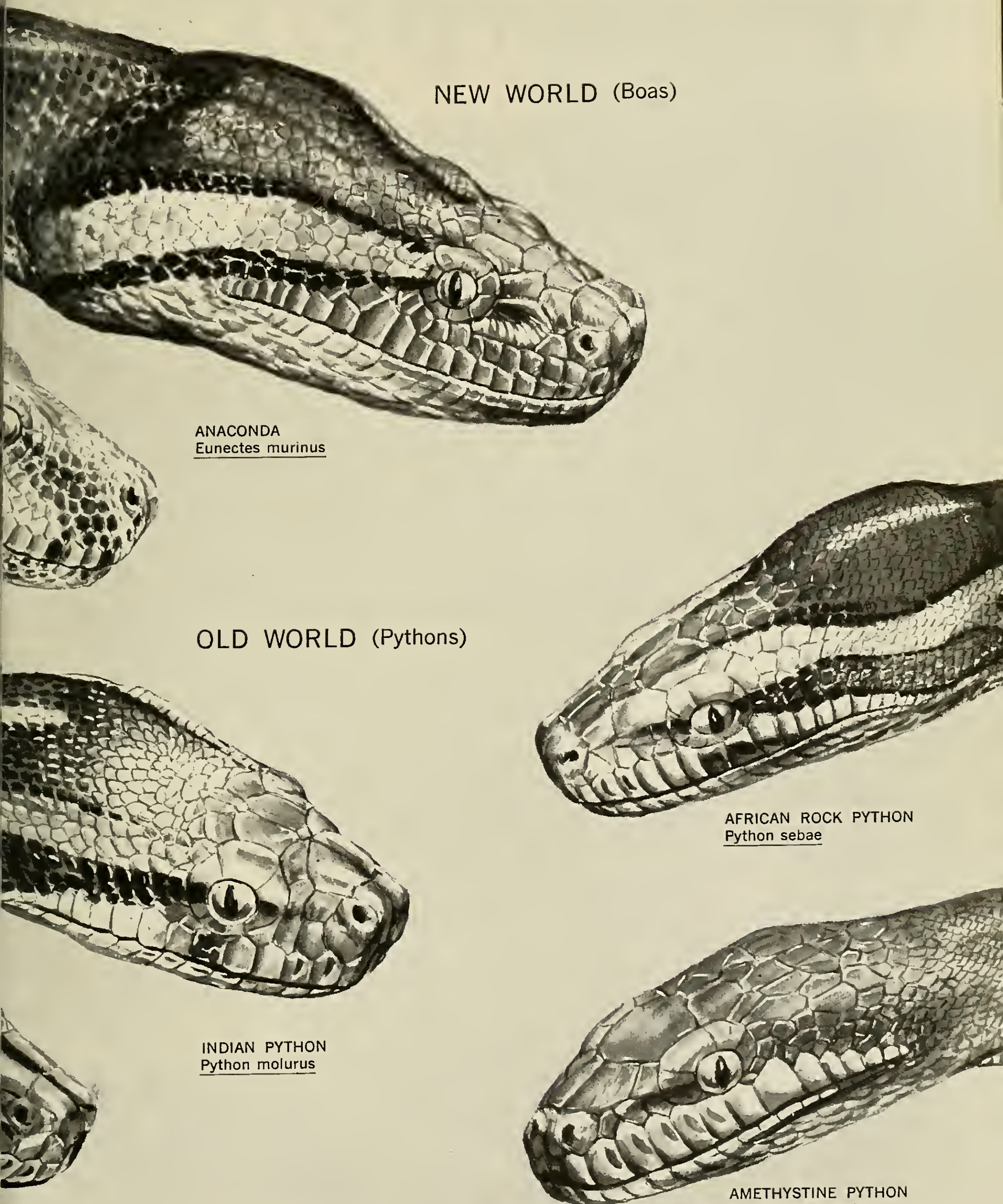
A quaint belief was heard in Burma by a scientist whose cook volunteered the information that a python, after digesting a large mammal, will "hang itself by the tail over the branch of a tree and shake its head until the indigestible bones" come up.

Ethnologists and students of folklore find scientific value in working out the historical development of myths as well as the courses along which they have traveled. Many questions have yet to be answered. Peoples from all corners of the world credit snakes with intrinsically similar and fantastic feats. While this is evidence of the powerful imaginative quality of the human mind, did the stories spread from an ancient center of origin, or did man repeatedly invent them? In either case, the serpent, carried to unmeasured heights on wings of fancy, is apt to remain aloft indefinitely.



BOA CONSTRICTOR
Boa constrictor

RETICULATE PYTHON
Python reticulatus


NEW WORLD (Boas)
ANACONDA
Eunectes murinus
OLD WORLD (Pythons)
AFRICAN ROCK PYTHON
Python sebae
INDIAN PYTHON
Python molurus
AMETHYSTINE PYTHON
Python amethystinus

ART OF THE TWIN

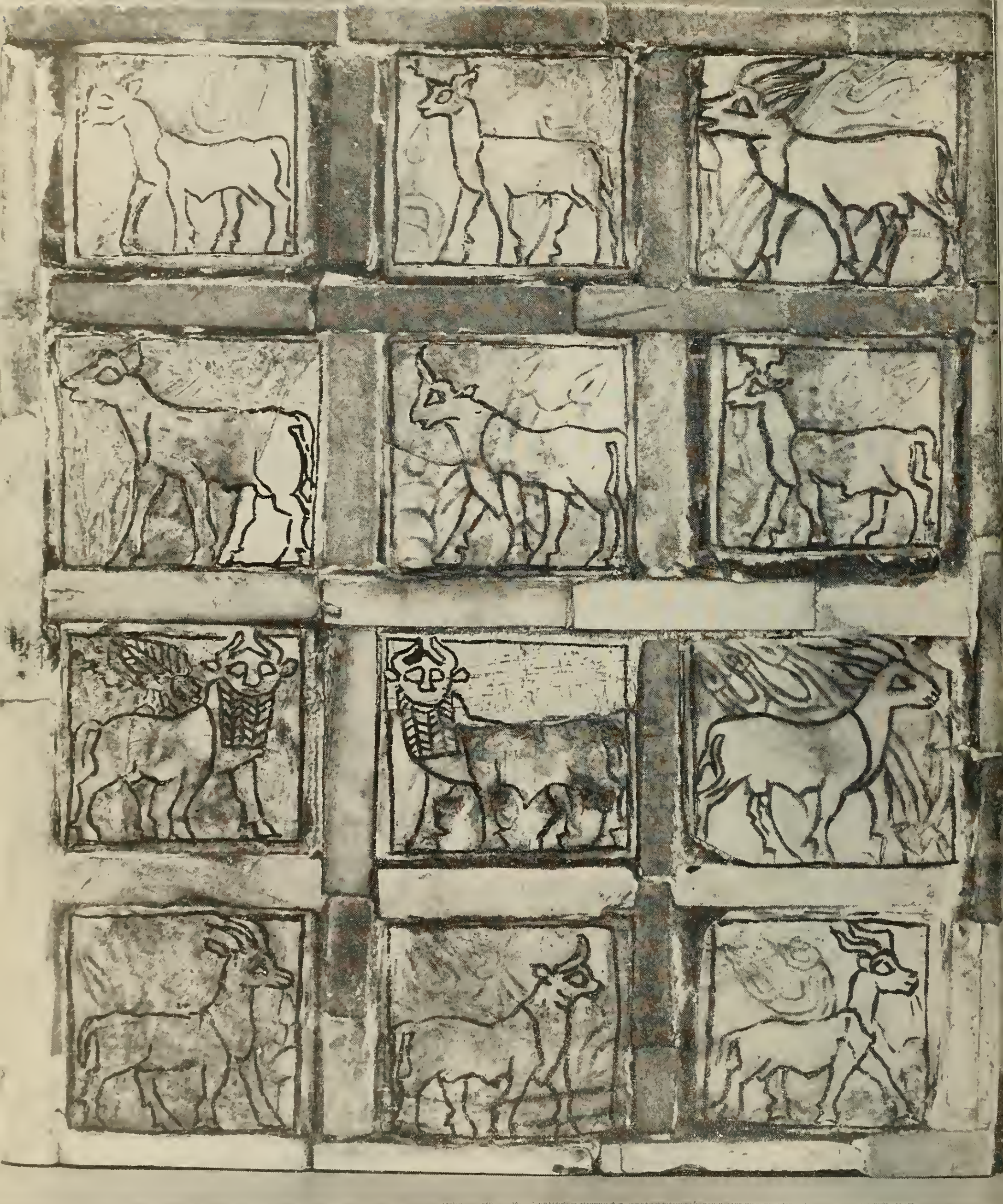
RIVERS

The Animals of Sumer

"This, then, is the story of a land. The trees are gone, the soil is gone, and the larger wild animals that are not gone remain but briefly." So write Robert J. Braidwood and Charles A. Reed in a pioneer study on the prehistory of northern Mesopotamia, *Prehistoric Investigations in Iraqi Kurdistan.*

Yet, in spite of the great changes that have occurred, the art and literature of the past, combined with the excavation results of zoologically minded archeologists, furnish us with a picture of the ancient landscape and the ani-

Strength and dignity characterize lion on terra cotta plaque from Nippur. Shell inset of harp on the cover is above.



Gaming board of shell sealed on wood with bitumen has been reconstructed. It was made at Ur about 2500 B.C.

Lion's head stamp seal of pink limestone, *upper left,* and reclining stone bull, *lower right,* were both made about 5,000 years ago. Terra cotta camel and baked clay equestrian date from *ca.* 1000 B.C. and 530 B.C. respectively.

mals that once roamed there. From excavations in caves such as Shanidar, Palegawra, and Hazer Merd have come the bones of animals that were killed and eaten by men of the late Stone Age before they had learned to live in villages and raise crops of grain. Among these bones are those of wild boar, wild ox, wild sheep, wild goat—ancestors of some of our principal domesticated animals. Domestication was possible, of course, wherever such wild ancestors were found. In the case of the wild ox and wild pig, for example, domestication could conceivably have occurred in the Nile Valley, Europe, India, or the Far East. Africa south of the Sahara, Oceania, and the New World are automatically ruled out because none of the wild ancestors of these four animals lived there. Archeological remains show us, however, that people in the Mesopotamian area began living in villages and raising crops sometime between ten and six thousand years B.C.; that is, earlier than in any of these other regions. Nevertheless, it is difficult to demonstrate conclusively that such early men kept animals. For many years archeologists did not salvage animal bones for study. In addition, considerable time elapsed before the bones of early domesticated animals began to exhibit sufficient morphological differences from those of their wild forebears to be distinguishable when excavated.

Like most peoples of the preindustrial world, ancient Mesopotamians made use of the wide range of raw materials in the land around them. These raw materials included those animals, both wild and domestic, that were able to contribute to man's practical life in the form of substances for everyday use (fur, skin, and sinew; blood, milk, and fat; meat, bone, and

The author, ROBERT H. DYSON, JR., is Assistant Curator, Near Eastern Section of The University Museum, University of Pennsylvania. He is also the director of the Hasanlu Project of that museum, The Metropolitan Museum of Art, and the Archeological Service of Iran. LEE BOLTIN photographed specimens at The University Museum especially for this story.

horn; and dung). They also formed the basis for additional human activities (herding, milking, shearing, slaughtering; the preparation of dairy products and textiles; and so on), and an increase in social tensions (theft, injury, hiring, buying, and selling). At the same time, animals also provided raw material for man's symbolic life. Their qualities were borrowed in describing gods and mythical creatures; myths were made up around them; they were used as decorative motifs in the arts; and they became important in religious ceremonies. Sumerian cuneiform texts, known especially from copies made about 1800 B.C. at the city of Nippur, mention many animals while dealing with a variety of subjects. One of these tablets contains a listing of the following types of animal skins:

"Ox, sheep, goats, ass, she-ass, wild ox, elephant, mountain elephant, wild cow, hyena;

"Deer, wild sheep, gazelle, young gazelle, fox, crocodile, hedgehog, lion, lioness, wolf, wild dog, badger, tiger, cheetah;

Sites of Mesopotamian cities lie in "Fertile Crescent" formed by the Tigris and the Euphrates rivers.

"Mouse, garden dormouse, brown rat, field mouse, vole, variegated mouse, rat, shrew, mongoose, and weasel (?)"

The wild animals mentioned most frequently in the written records of the Sumerians and their successors, the Babylonians and Assyrians, are usually predatory. The need for respite from the incursions of these wild beasts is indicated in the second millennium Old Babylonian version of the Gilgamesh Epic, in which Enkidu, faithful friend of the heroic Gilgamesh, ". . . caught wolves and lions so the cattlemen could lie down at night."

THE wild bull and the lion often appear as symbols of strength. The lion became one of the favorite subjects of artists working in metal, stone, and clay. In some scenes, often those inscribed on seals, the lion is shown grappling with a hero. In others he is shown biting the neck of some animal, as in the famous cosmetic box lid from the Lady Shub-ad's tomb at Ur. Stamp seals of the Jemdet Nasr period, roughly 3000 B.C., were often made in the shape of a lion's head. Lions were so common and such a nuisance around 1800 B.C. that a few years later Hammurabi included in his law code special laws concerning animals killed in the open or in the sheepfold by lions.

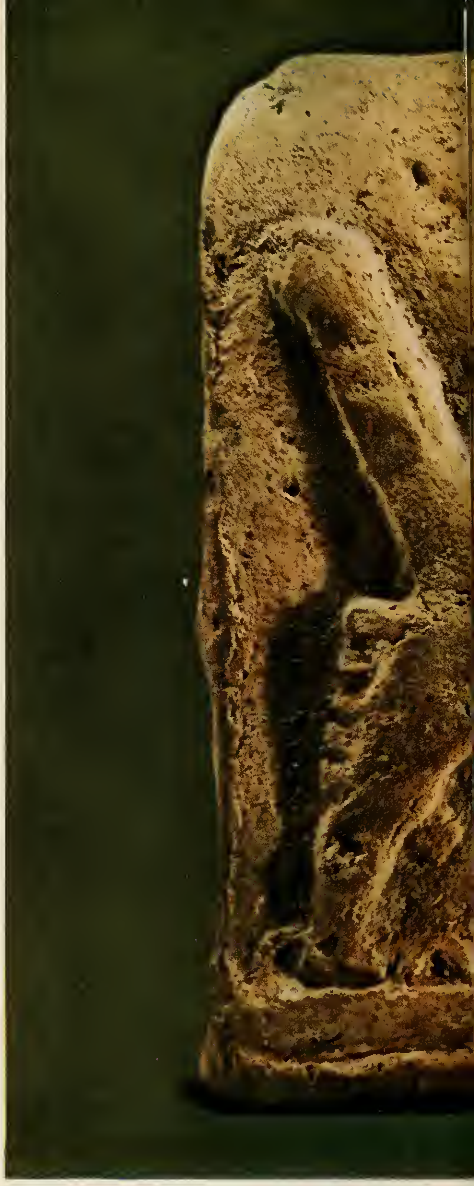
The lion was also regarded as a proud animal, as shown by its rendering on a clay plaque from Nippur. Such proud strength was a suitable attribute for use as a measure of the stature of a ruler or a city. Thus, in paying tribute to the king Shu-Sin in a love song written approximately 2000 B.C., its writer uses a simile to imply the king's superior power by declaring that Ur "lies at thy feet like a lion-cub." In a much later text a patient describes his recovery from a disease as an act of a god: "Into the mouth of the lion who was devouring me Marduk places a bit." For all the lion's fierceness, the Mesopotamian also recognized its capacity for anguish. At the death of Enkidu, Gilgamesh is described as:

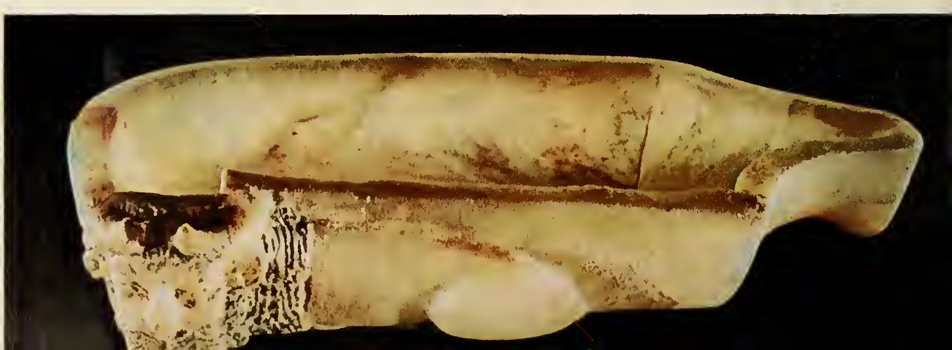
"Storming over him like a lion,
Like a lioness deprived of [her] whelps."

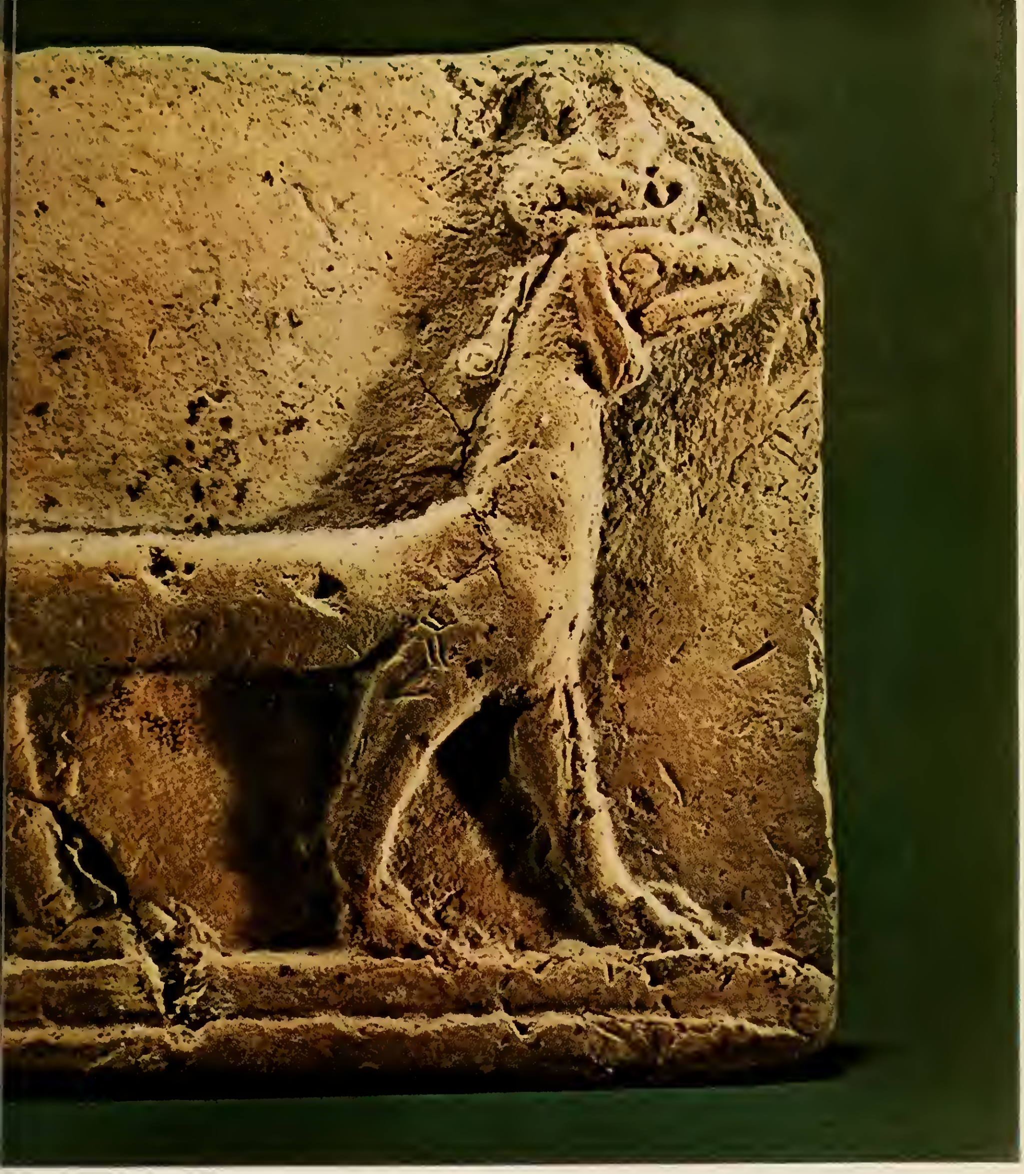
While the Sumerians were especially aware of lions and bulls among the wild fauna of their country, they were equally cognizant of much

Fleece of goat among gold leaves is shell and lapis lazuli. Beard, eyes, and horns are also lapis.

"The enemy of the herds, the lion," feeds on its prey
on decorated cosmetic box lid, *ca.* 2500 B.C.,
which was found in grave of the Lady Shub-ad at Ur.







Mythological monster from Nippur is composite of several creatures. It has lion haunches, bird-claw feet, and its snakelike head wears a crown.

Bearded bull forms side of alabaster vessel similar to that carried by lion on harp inlay (cover). The bull, too, is reminiscent of the one on the harp.

Inlays of shell form eyes and decorative dots on this beautiful, hollow-cast head of goat, found at Fara.

Deer of gold foil on bitumen cores, gold fruit and grain adorn a beaded diadem of the Lady Shub-ad.

smaller creatures. Thus we find sayings such as: "When ants are struck, they do not accept [it passively], but bite the hand of the man who smites them." Elsewhere, the writer of a lament cries, "My possessions like heavy locusts on the move . . . have been carried off."

All of these animals had a history stretching far back into the Ice Age (or Pleistocene epoch). Civilization grew up in their midst, causing their extinction or forcing them from their original habitats back into the mountains.

Take the domestic dog, for example. Its ancestor is still uncertain; it may have been a wolf, a golden jackal, or some kind of wild dog. In Mesopotamian art, dogs are first known at the village of Jarmo around 6500 B.C. in the form of little clay figurines with upcurled tails. Actual bones are unknown, however, until the Ubaid period, nearly three thousand years later. The skull of a saluki-like dog found in this period at the site of Tepe Gawra shows, along with seal representations, that a lean, short-haired hunting dog had come into existence. In later days some of the domestic dogs were used for protecting the herds.

The domestic pig is even more elusive in the archeological record. Bones of a large-sized pig occur in infrequent numbers at Jarmo, but there is no evidence that these were domestic as opposed to wild animals. Other bones have been found at sites like Nineveh and Tell Hassunah in early levels, but have never been studied. As in the case of the dog, it is not until much later that evidence is at hand in the form of art representations and script signs to show the existence of a domestic variety.

Of the earlier domestic animals, the most important, both to the practical and to the symbolic life of the Mesopotamians, were sheep, goats, and cattle. Of these, cattle figured most prominently, as indicated by the fact that over fifteen laws in the Hammurabi law code deal with oxen, whereas only two or three deal with sheep. Literature of the period indicates that wild cattle still roamed the forest, no doubt descended from the same long-horned wild cattle found in the sites of Stone Age hunters, the earliest of which is Barda Balka near Jarmo, dated about 75,000 years ago. More recently, a small form of wild cattle has been identified at Shanidar Cave in a level dating back some 40,000 years. The presence of both a large and a small wild form so long ago in northern Mesopotamia raises an interesting question in animal ancestry, for both large and small domestic cattle were among the tribute given to the Assyrian kings from peoples living in the same area during the first millennium B.C.

Bulls, and cows to a lesser extent, found

Ram's head, delicately carved in black stone at Ur about 1700 B.C., probably was used on a staff.

their way into the art of the Sumerians and later peoples in a variety of ways. They occur as sculpture in the round and in relief on plaques and bowls of stone and terra cotta, as inlay pieces of shell, and carved on stamp and cylinder seals. They are equally abundant in metal. Gold, silver, and bronze heads were fashioned in the round as ornaments for musical instruments, furniture, and jewelry. Metal vessels, plaques, fillets, and other objects were decorated with the chased outlines of animals. Even shell gaming boards have squares decorated with bulls and cows in outline form.

SEVERAL notable objects involving animals are shown in the illustrations accompanying this article. They are largely from The University Museum's collections from Ur, excavated by the late Sir Leonard Woolley between 1923 and 1934, and from the Nippur excavations of H. V. Hilprecht in the 1890's. The raw materials used, with the exception of terra cotta, had been imported to the valley of the Tigris and Euphrates rivers from foreign lands, as the alluvial plain itself lacked them. Lapis lazuli was probably brought overland from Afghanistan through Iran; thick sea shells

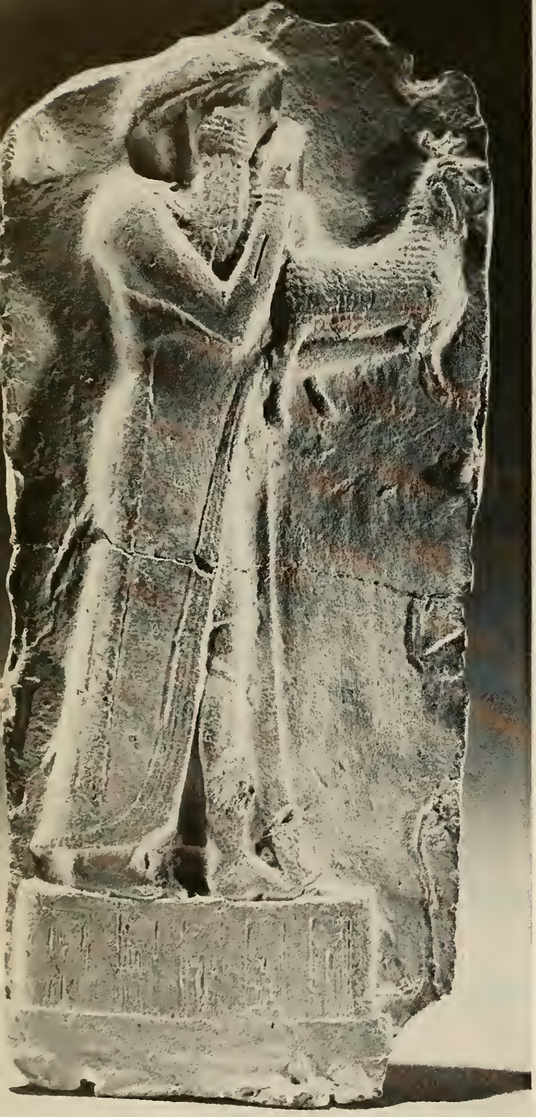
were brought in from the Persian Gulf and the Indian Ocean; carnelian may have come from the Indus Valley, where stone virtually identical in quality to that of the beads of the Royal Cemetery at Ur was used for similar jewelry at Mohenjo-Daro. Steatite and alabaster probably came from Iran; while metal ores such as gold, silver, and copper may have been brought from either Iran or Turkey. In some instances, these materials were used singly, but more often they were combined. The lapis lazuli, for example, often formed a beard or part of an eye set off by white shell, as in the bull's head from the Early Dynastic harp at Ur *(see cover)*.

Another remarkable combination of materials may be seen in the figure of a standing he-goat nibbling at a golden tree, a piece sometimes erroneously called "The Ram in the Thicket." The animal's body was originally a wooden core onto which a covering of silver, and white shell and lapis fleece were attached. The beard, eyes, and horns were also of lapis lazuli. A companion piece is in the British Museum. The two, found near each other, were presumably supports for a small piece of furniture, perhaps an offering stand, as shown by the dowel protruding up from the shoulders.

Curiously, although the practical aspect of keeping cattle is seen in early seal impressions that show milking scenes, oxen are rarely shown in preserved representational art as pulling wagons or plows or otherwise domestically engaged. The rarity of such representations no doubt is due to the preoccupation of artists with the religious, rather than the secular, life. Written records supply the missing data. Hammurabi's code decrees the fee for hiring an ox to thresh at twenty *qu* (measures) of grain per day (an ass cost twenty, a goat one). Threshing was undoubtedly done in part by having the animals walk in a circle trampling the grain, as it is still done today in areas lacking modern farm machinery. It is interesting to note that the fee for renting an ox for a year was four *kur* (measures), while the cattle herder himself rated only six! The value of an ox is further shown by laws recording fines for the injury of any part of a rented animal. The owner of a vicious bull was also constrained by law: "If a seignior's ox was a gorer and his city council made it known to him that it was a gorer, but he did not pad its horns [or] tie up his ox, and that ox gored to death a member of the aristocracy, he shall give one-half *mina* of silver." Other laws covered veterinary surgery on an ox or an ass: one-sixth shekel of silver for a successful operation; one-fourth the animal's value if it died. Theft was severely punished. Stealing an ox, sheep, ass, pig, or goat cost tenfold if from a private citizen, thirtyfold if from the temple.

The role of the animal in the symbolic aspect of communal life may be indicated by the ritual involving the replacement of the head of the temple kettledrum. The eligibility of the bull was strictly defined: it had to be unmarked by a goad, to have no white tufts, to have whole horns and hoofs, and to be black as pitch. It was then brought to what was called the *mummu*-house and set on a reed mat with its legs tied with a goat hair rope. After the offering of a sheep, the ritual of "washing the mouth" was performed by whispering an incantation into the bull's ear through a reed and then sprinkling him with cedar resin. He was then purified symbolically in some way with a brazier and torch. Around him a circle of flour was made and, after further recitations by the priest, he was killed with a knife. The heart was burned with cedar, cypress, and a special kind of flour in front of the kettledrum. The tendon was removed from the left shoulder for some reason not specified, and the animal was skinned. The body was then wrapped in a red cloth and buried facing west. Elaborate instructions were then given for the preparation of the hide, which

On terra cotta plaque, *ca.* 2500 B.C., humanized bull stands on stylized hill and is attacked by eagle.



Babylonian worshiper speaks confidentially to his god and offers lamb. Plaque is over 3,500 years old.

would eventually serve as the new drumhead.

The laws also dealt with sheep, their pasturing, and the care of the flock. For example, a careless shepherd who allowed lameness to develop in his flock is conjoined to make the loss good to the owner. The references to sheep in the law codes, and the common appellation of "shepherd" to the various deities, is indicative of the importance of sheep herds to the economy and daily life. This emphasis is interesting when we realize that the goat, not the sheep, was apparently the earlier in domestication, as indicated by a study of horn cores dating to 6500 B.C. recovered from the Jarmo excavations. These horns have the same tendency to twist in homonymous form as seen in the later domestic screwhorn goats.

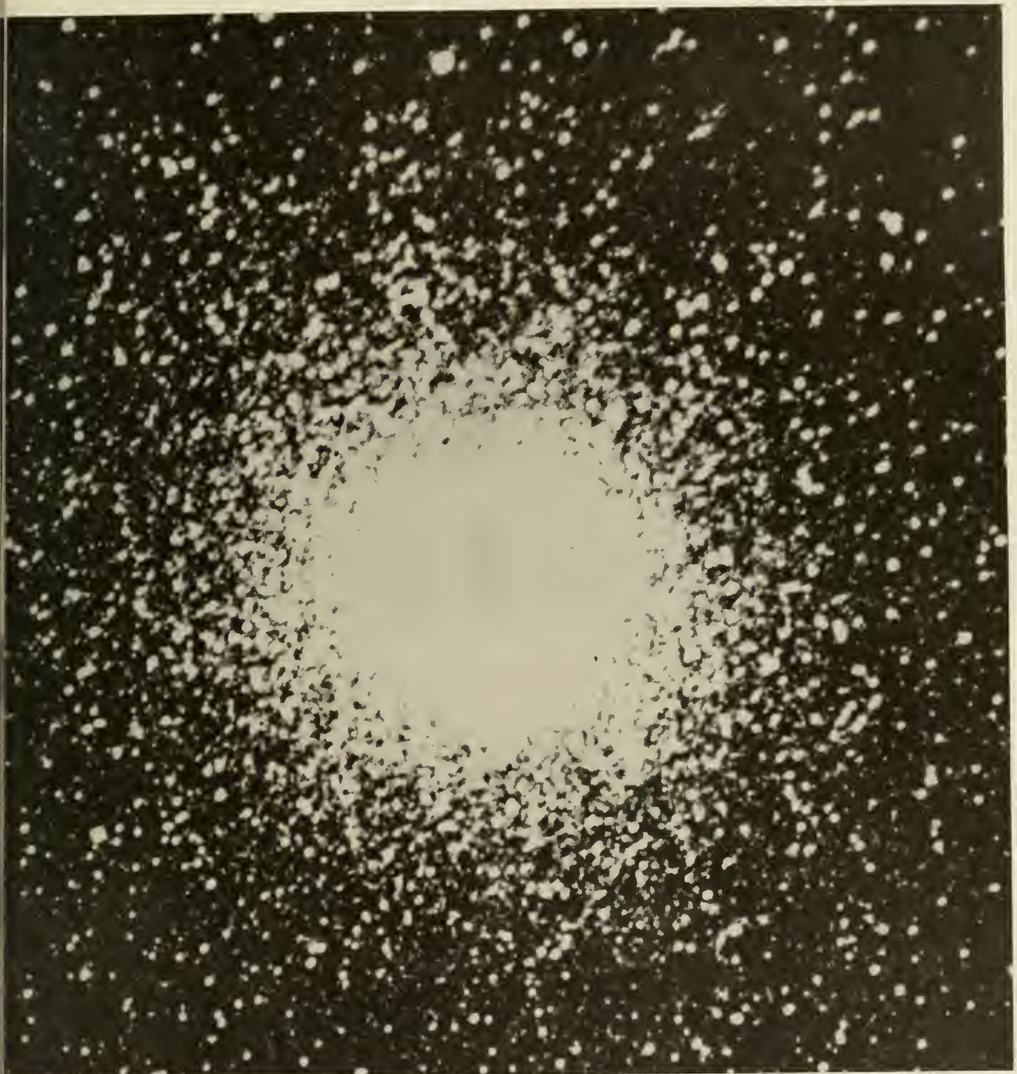
ALL of the animals of the Mesopotamian world were drawn upon for the creation of mythological beings and monsters. The poems of creation, of Gilgamesh, and of the nether world are inhabited by these monsters compounded from various animals. The Akkadian Creation Myth, known from a copy made in the first millennium B.C. but thought to date to the second, illustrates a few of these:

"Roaring dragons she has clothed with terror,
Has crowned them with haloes,
making them like gods,
So that he who beholds them
shall perish abjectly.
And that, with their bodies reared up,
none might turn [them back].
She set up the Viper, the Dragon,
and the Sphinx,
The Great-Lion, the Mad-Dog,
and the Scorpion-Man,
Mighty Lion-Demons, the Dragon-Fly,
the Centaur. . . ."

Such fantastic monsters inevitably entered the art world, and appeared in scenes on plaques and seals. An excellent example of a composite type of monster such as those mentioned in the passage quoted above may be seen in the terra cotta plaque from Nippur (page 35), which is a combination of lion, bird, and snake.

The animals of ancient Mesopotamia were an essential part of the environment within which man lived; now attacking him, now falling victim to his attacks; now serving him and adding to his well-being, now leading to conflict with his fellow man. They were tribute to his conquerors; offerings to his gods. They enriched his art and fired his mind. They lived as much in his world of imagination as they did in the world of reality. In this way they formed a basic portion of the Mesopotamian world—a world of towns and wilderness—and of dreams.

Clay seal impression shows milking scene at Ur about 3000 B.C., with cattle emerging from reed huts.

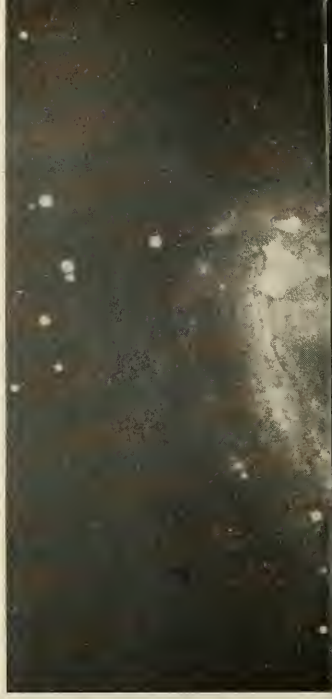


SKY REPORTER

Study of southern sky began during the mid-eighteenth century

By Simone Daro Gossner

THE MAGNIFICENT GLOBULAR CLUSTER pictured above bears the name of 47 Tucanae. It is one of the many beautiful objects located so far south on the celestial sphere that they cannot be seen from our latitudes. To the naked eye, 47 Tucanae appears as a hazy spot, but powerful telescopes reveal its dense conglomeration of thousands upon thousands of giant stars. It is some 20,000 light-years away and is intrinsically the brightest known globular cluster (in other words, if all such objects were at the same distance from us, it would outshine every one). In the past few years, studies of individual stars belonging to the cluster have revealed another peculiarity that sets it apart from all others: whereas globular clusters usually contain stars similar to those found in the central nucleus of



Southern Hemisphere galaxies of great beauty are, from left, NGC 253, a spiral galaxy; NGC 1365, fine example of

galaxies—a composition ascribed to old age—the stars in 47 Tucanae represent a transitional stage between these very old objects and the younger stars found in spiral arms. Thus, besides being the brightest of all globular clusters 47 Tucanae may also be the youngest one.

Among constellation names, that of Tucana (the Toucan) is probably much less familiar than the mythological ones. This could be said, too, of others such as Chamaeleon, Octans, Dorado, and Horologium. Of course, they are not visible here and we have fewer opportunities to use their names. Yet the principal reason for their relative obscurity is that they were named in the seventeenth and eighteenth centuries, two thousand years after the others had become known through ageless tradition. Until the great exploratory voyages began, skies above the South Pole were virtually unknown to most of the civilized world.

Johannes Bayer, in *Uranometria* (1603), made the first systematic attempt at grouping southern stars into constellations, which he named mostly for animals, real and fabulous: Dorado (the Swordfish), Musca (the Fly), Monoceros (the Unicorn), and so forth. A few decades later, other groups were added by Hevelius, but, for the most part, the names he chose eventually fell into disuse. At mid-eighteenth century, the southern skies were still so poorly charted that mariners were often endangered by the lack of suitable star maps. In the area of the Cape of Good Hope, for example, there were many instances when ships caught in bad weather missed the harbor altogether, because the absence of astronomical data had precluded accurate determination of the Cape's geographic position.

In 1751 the French Abbé Nicolas de Lacaille came to Capetown for the express purpose of charting the southern stars. Working alone for about two years, he assigned boundaries and names to southern constellations, catalogued about 10,000 stars, and determined the geographic co-ordinates of the city. In a startling departure from previous tradition, Lacaille named his new constellations for scientific paraphernalia: Horologium (the Clock), Antlia Pneumatica (the Air Pump), Sculptor (the Workshop), and Fornax (the Furnace) are examples of his system.

After Lacaille had returned to France, astronomy lay dormant once more in the Southern Hemisphere. At the beginning of the nineteenth century astronomical interest had shifted from studies of the solar system to that of stars and nebulae, mostly as a result of the pioneering work of Sir William Herschel. In contrast to observations of planets, which could always be made north of the Equator, the new research programs made it desirable to observe the entire celestial sphere. The first southern observatory was founded at Capetown in 1820, and was placed in full operation in 1828. Shortly thereafter (1834-1838) Sir John Herschel came to the Cape on a private expedition to extend to the Southern Hemisphere his father's catalogue of nebulae and clusters. In 1858, the first of several Australian observatories was founded at Sydney, and in 1870 the first South American observatory was established at Cordoba, Argentina. Several northern observatories followed suit by setting up field stations south of the Equator.

A pioneer among these was the Harvard Observatory station at Arequipa, Peru, which was kept in continuous operation from 1890 to 1926 (it was then moved to Bloemfontein, South Africa). At Arequipa was begun the most extensive survey of southern galaxies that has ever been

ı barred spiral; and NGC 613, a barred spiral with arms of ınusual complexity. The last is a source of radio emission.

ɔublished. There, too, were obtained the photographs of the Magellanic Clouds, from which Harvard astronomer Henriεtta Leavitt derived, in 1905, the now famous *period-lumiıosity relation* of cepheid (pulsating) variable stars. The Magellanic Clouds, which we will discuss again later in this series, are small galaxies, satellites of our own Milky Way. They are sufficiently remote so the stars they contain may be treated as being all at the same distance from us. When comparing her measures of the cepheids' apparent brightnesses with their pulsation periods, Miss Leavitt discovered that the brightest ones have the longest periods, and that the periods grow progressively shorter as the brightness decreases. Since all the cepheids measured by Miss Leavitt are equally distant from us, the newly discovered relationship had to hold true also for the intrinsic brightness of those stars. Remembering that the difference between the intrinsic and apparent brightness of an object yields a measure of its distance, one may thus use the observed period of a cepheid to derive its intrinsic brightness and its distance, and hence the distance of the cluster or galaxy in which it happens to be situated.

In the same way that the cepheid period-luminosity relation provided a powerful yardstick to measure distances of nearby galaxies (the more distant ones are too far away to show individual stars), Hubble's discovery at Mt. Wilson in 1929 yielded a similar yardstick for the remote ones. He found that the speed of recession of galaxies—the so-called red shift—is greater as their distance increases. This felicitous combination of circumstances gave the initial impetus to studies of the structure, nature, and extent of the universe—studies that continue to accelerate. The part played by Southern Hemisphere observatories in securing observational data has been essential in this area of research. Milky Way surveys at Bloemfontein and at the Mt. Stromlo Observatory at Canberra, in particular, have revealed the detailed structure of the region that lies in the direction of the nucleus of our home galaxy.

In the realm of galaxies, the recent studies carried out by the staff of the Royal Cape Observatory deserve special commendation. During the last few years, with the cooperation of the Radcliffe Observatory at Pretoria, they have obtained large-scale photographs of a number of galaxies chosen with particular regard to their scientific interest. Many of these objects happen to be strikingly beautiful as well, as witnessed by the three photographs reproduced above. The spiral galaxy NGC 253, *left*, in Sculptor, was first observed by William Herschel. It is seen almost edge-on, but its spiral arms are nevertheless well discernible. This galaxy is *approaching* us with a speed of about 45 miles per second, a fact that indicates its relative nearness (that is, the general effect of recession common to all galaxies is not sufficient, at NGC 253's distance, to mask its individual space motion). NGC 613, *right*, also located in Sculptor, is of the type called "barred spiral," in which the arms stream from extensions of the nucleus rather than from the nucleus itself. A superb example of a barred spiral is NGC 1365, *center*, in Fornax. Its bar is even longer than it appears here, because the galaxy is tilted in respect to our line of sight. One should note in particular the well-defined zigzag pattern at the center, a characteristic feature common in barred spirals. Quite noticeable also are the dark lanes of obscuring matter, especially those found on both sides of the zigzag.

THE SKY IN JUNE AND JULY

From the Almanac:

New Moon	June 2, 8:27 A.M., EST
First Quarter	June 10, 1:22 A.M., EST
Full Moon	June 17, 9:03 P.M., EST
Last Quarter	June 24, 6:43 P.M., EST
New Moon	July 1, 6:53 P.M., EST
First Quarter	July 9, 6:40 P.M., EST
Full Moon	July 17, 6:41 A.M., EST
Last Quarter	July 23, 11:19 P.M., EST
New Moon	July 31, 7:24 A.M., EST

The summer solstice, which marks the beginning of summer in the Northern Hemisphere, will occur on June 21 at 4:24 P.M., EST. On July 4, the earth will be at aphelion—the point in its orbit farthest away from the sun.

For the visual observer:

Mercury will be in inferior conjunction on June 7 and will enter the morning sky on that date. It will reach its greatest western elongation (22°) on July 1 and will be in superior conjunction on July 29. Therefore, it will be observable mostly in the last few days of June and in early July. During that period, it will rise in the northeast about an hour and a quarter before the sun.

Venus, in the evening sky, will set approximately two hours and a quarter after sunset in June and July (two hours after sunset by July 31). It will be found in the western sky at dusk. On June 11, and for a few days before and after that date, it will be south of Castor and Pollux.

Mars, in Taurus (+1.4 magnitude), will rise at 2:45 A.M., local standard time, on June 1, 1:45 A.M. on June 30, 12:45 A.M. on July 31. The planet, visible in the eastern sky before sunrise, will be south of the Pleiades in early July and north of the Hyades about two weeks later.

Jupiter, in Aquarius, will rise at 12:30 A.M., local standard time, on June 1, at 10:45 P.M. on June 30, and at 8:30 P.M. on July 31. The planet will be in the southern sky before sunrise. It will brighten somewhat from —2.1 magnitude in early June to —2.3 in late July.

Saturn, in Capricornus, will rise at 11:15 P.M., local standard time, on June 1, 9:15 P.M. on June 30, and at sunset on July 31, and it will remain visible until sunrise. This planet, too, will increase slightly in brightness from +0.7 magnitude in June to +0.5 in July.

The Delta Aquarids meteor shower will attain its maximum on July 29. A single observer may see about 20 meteors per hour, with little or no interference from the moon.

Eclipses:

A penumbral eclipse of the moon will be visible in most of the United States in the early morning hours of July 17. For the earth in general the eclipse will last from 5:27 to 8:21 A.M., EST, but in the Western Hemisphere the moon will set before the end of the phenomenon. Penumbral eclipses are characterized by a gradual decrease in the moon's brightness, without sharp delineation of shadow.

An annular eclipse of the sun will occur on July 31. The annular phase will start in Venezuela, traverse the Atlantic Ocean and central Africa, and end in the Malagasy Republic. The eclipse will not be seen in the United States, except for a small partial phase visible at sunrise in Florida.

On the preceding pages, MRS. GOSSNER offers the sixth in her 1962 series—a survey of the celestial sphere.

To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.


north
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
LYNX
northwest
CAMELOPARDALIS
POLARIS
NORTH POLE
URSA MAJOR
POINTERS
LEO MINOR
LITTLE DIPPER
BIG DIPPER
ALCOR
MIZAR
DRACO
REGULUS
CANES VENATICI
LEO
COMA BERENICES
VEGA
ZENITH
Great Cluster
BOOTES
DENEBOLA
VENUS July 31
June 10
west
HERCULES
CORONA BOREALIS
ARCTURUS
SERPENS
July 6
VIRGO
OPHIUCHUS
SPICA
CORVUS
June 14
LIBRA
July 13
ANTARES
SCORPIUS
CENTAURUS
southwest
LUPUS
TIMETABLE
June 1 12:00 P.M.
June 15 11:00 P.M.
July 1 10:00 P.M.
July 15 9:00 P.M.
July 31 8:00 P.M.
(Local Standard Time)
south

Diversity Typifies Heron Feeding

Specialized foraging techniques permit species to coexist

By Andrew J. Meyerriecks Drawings by Guy Tudor

THE PRIMARY FOOD of many heron species is fish, and the birds are v adapted for the pursuit, capture, n consumption of such prey because ong bills, necks, and legs. Indeed, h e and other striking structural ptations of herons are often cited n popular and technical articles to port the contention that herons are is catchers par excellence. It is far n general knowledge, however, that he lovely birds display a remarkable diversity in their feeding behavior.

The classic heron feeding technique is to stand "frozen" in the shallows, waiting for prey to come within striking range, but herons also pursue their prey actively in many ways, some characteristic of one species, others shared by several species. In Florida Bay, as many as nine species of herons can be seen feeding on the same shoal, but rarely are more than two or three species seen to use the same or similar feeding methods simultaneously. In fact, individuals of some species (for example, the reddish egret, *Dichromanassa rufescens*) may reveal the entire feeding behavior repertoire of that species in less than an hour of close observation.

My purpose here is to describe some techniques used by the North American herons with which I am most familiar and to relate this diversity of behavior to certain aspects of heron

"MAINTENANCE" ACTIVITIES of an adult little blue heron
that occupy bird when not foraging include using nail of

ecology. Further, I shall speculate briefly on the origin and evolution of heron feeding behavior—speculative because behavior does not fossilize, and the feeding techniques of many species are not (or are poorly) known.

I call the basic type of heron feeding behavior "stand and wait," and to my knowledge it is common to all species of the family Ardeidae. This basic method is highly characteristic of the green heron, *Butorides virescens,* a species broadly distributed in North America. Typically, a feeding green heron takes a stance at the edge of a pond or a tide pool and remains motionless in a low, hunched posture, with its head retracted. Often the first indication that prey has drawn near is a slight up-and-down "tail-flicking." I do not know the reason for this tail movement before a strike, but it is a regular pattern. When the prey, say a minnow, is in range, the green heron strikes by darting its head forward and down. The fish is seized and held for a moment between the tips of the long, slender mandibles. Then the heron tosses the food headfirst into its mouth by a short, backward motion of its head. Often a green heron will dip its bill into the water after capturing aquatic prey; this behavior is usually followed by a quick shake of the bird's head. I have noted that when a green heron misses a strike, it will usually show the bill-dipping and head-shaking anyway, as if this follow-through were essential to the feeding sequence.

If the prey is too large or too active to swallow when captured, green herons (and other species) will batter it against roots, rocks, or the ground before eating it. Sometimes the bird will drop, strike, and pick up the prey repeatedly until it is ready for consumption. On one occasion I watched a crippled common egret, *Casmerodius albus,* work over a very large fish in this fashion for one hour before finally giving up and hobbling over to a deep pool for another try.

An obvious modification of the basic feeding method is "wade or walk slowly"; I believe that this technique is also common to all herons. The common egret is a master of this method. It wades or walks slowly among dense cattails or flags in a pond, through a reed-choked habitat, or even in the short grass fields of a dry, upland locale. The bird moves slowly, each step seemingly measured; it may hold its body erect, head and neck forward at about a 45° angle, or it may adopt a low, crouched posture with its head slightly retracted. The latter pose is usually shown by an egret foraging in areas with dense aquatic vegetation. A common variant is one I have labeled "peering-over," in which the egret stalks from a low, crouched posture, head fully extended, with bill pointing down or nearly so. This pose seems to be characteristic of situations in which the prey has moved under cover and the egret is trying to locate it with the least bodily motions.

The function of this method is clear: when the prey does not come to an immobile egret, the bird is forced to seek it out stealthily. When the prey makes its presence known, the egret halts, often with one leg slightly raised in a stop-motion, fixes its gaze on the prey, retracts its head slightly in

middle toe to scratch head, *left;* preening flight feathers, center; and preparing to strike at prey beneath its perch.

preparation for unleashing its bill, then strikes at the target.

The little blue heron, *Florida caerulea*, another master of the slow wading method, is an example of a species with a common variant of this technique — "head-tilting." The feeding heron wades forward as described, but regularly and alternately tilts its extended head and neck sharply to one side of the main body axis and then to the other as it peers at the water. My observations indicate that little blue herons use head-tilting most often on bright days, when there is considerable surface glare on the water, or when foraging in shallow water habitats with thick vegetation.

The two basic methods, "stand and wait" and "wade or walk slowly," form the hard core of heron feeding behavior. They are common to all herons and are often resorted to when more sophisticated techniques fail. Although of interest, especially to the student of heron behavior, the basic methods seem unspectacular compared to the exciting and often bizarre foraging methods used by many herons when pursuing prey. Many of these techniques fit the collective category of "disturb and chase."

If we watch patiently, for example, a wading great blue heron, *Ardea herodias*, or a little blue heron, we can see a bit of the past unfolding before us, because the bird will show the first link in what I conclude is an evolutionary series of active prey-pursuits, culminating in other species in the most bizarre of heron feeding methods —"canopy feeding"—which will be discussed later. This link is a seemingly trivial bit of behavior that I have dubbed "wing-flicking."

The wading heron moves forward at a stately pace, then does what at first glance appears to be a balancing movement: it suddenly extends and withdraws both wings in a short, rapid flick. The extension of the wings may be barely perceptible or may be a noticeable motion of a few inches to about a foot. Typically, two or three such wing flicks are given in succession, although five or more are not uncommon. The bird may stop wading, give several wing flicks, then move on, or it may flick as it wades. Rarely, the bird will stop, give a single wing flick, wade a few steps, then repeat the behavior for several minutes. I conclude that the function of wing-flicking is to startle prey into activity, thus enabling the heron to locate and strike at food items not previously disturbed by its wading. Most of my observations of this method have been made on bright days when the herons were foraging in open, shallow waters. Each wing flick made a sudden, obvious shadow on the surface of the water. Now, it is true that the bird's shadow is on the water, but this moves slowly, whereas the wing flicks cast two sudden extensions of the moving shadow. When this device stimulates prey into movement, the heron strikes from a stationary stance or actively pursues its food.

The tricolored, or Louisiana heron, *Hydranassa tricolor*, shows clearly the next stage in the evolutionary story. When foraging, the bird may exhibit one or more variants, often in rapid sequence, of "open wing feeding." The

Two reddish egrets, one dark phase, the other in rarer white phase of the species, are shown in various stages of feeding territory dispute. Plumage is erected more as tendency to attack increases. If neither bird breaks of

wading bird, feeding typically in shallow, open water, will suddenly extend one wing fully, whirl, withdraw the wing, whirl, fully extend the same or the other wing, then rapidly pursue any prey disturbed by the quick wing movements. Or the heron may wade forward slowly, then pick up speed by running straight ahead, stop suddenly, move one or both wings out rapidly to their fullest extent, whirl in place, then stab at its prey.

One of the handsomest of New World forms, this species adds to its beauty of shape by pirouetting, a magnificent variant of the open wing technique. The bird starts by wading forward. It then extends both wings and starts to turn in place. Next, it raises one wing higher than the other, and as it turns slowly it tucks its head under the higher wing while peering into the water. Characteristically, the bird tucks its head under the raised wing when its back is to the sun. As it turns, the bird shifts its head to a position under the other wing, which has been raised during the pirouette. I have seen this method used on bright days when surface glare was intense; clearly, the pirouetting serves a dual function: (1) surface glare is reduced when the wing casts a shadow on the water and an eye shield is provided for the heron; (2) the erratic movements of the shadow cast on the surface of the water stir up potential prey.

The reddish egret, as far as its feeding behavior is concerned, is my favorite North American heron. It is unique among our species in the diversity and strangeness of its foraging methods. No other heron, to my knowledge, has such a varied and unpredictable repertoire. Although this species shows the basic methods. it characteristically pursues its prey in an energetic fashion. A reddish egret may commonly show wing-flicking, but more often it will lurch or reel about the feeding grounds in a half-running, half-jumping type of foraging behavior. More important for our evolutionary thread. the reddish egret shows the two remaining links in our series. The first, "underwing feeding," may

he encounter, they meet in combative light, at center, and contest the area.

precede or follow any of the methods previously described, which is a good indication of the bird's versatility and unpredictability. From a forward run or a weaving type of progression, the egret will suddenly stop and extend one or both wings fully and horizontally. While holding this pose, it stabs rapidly under one or both wings. Unlike open wing feeding, in which the wing is extended fully and then withdrawn, the reddish egret holds the extended position as it strikes. The wings, however, are not raised appreciably above the horizontal, nor are they brought forward in front of the bird's head. This technique is a precursor, so to speak, of the final step in the evolutionary story.

By comparing a number of related forms, perhaps I have produced enough evidence to indicate that these patterns of feeding behavior, even though shown by living species, reflect an underlying evolutionary sequence that may have taken millions of years to perfect. The terminal twig in our phylogenetic branch is canopy feeding, best shown by an African species, the black heron, *Melanophoyx ardesiaca.* In this species, the extended wings are first brought forward, forming a canopy over the bird's body. The heron then tucks its head under the umbrella so formed and starts to feed. The black heron actually places the tips of the flight feathers in the water, or in special cases, in the soft mud of a pool-dotted substrate. Our own reddish egret does not carry this method to the extreme shown by the black heron, in that the tips of the flight feathers, at least to my knowledge, are not placed in the water. However, the reddish egret does form a canopy over its body, especially the forward parts, tucks its head under the covering, and waits for the prey—typically, small minnows—to gather under the canopy before striking. Prior to canopy feeding, the egret has been dashing about, stirring up the fish; now, however, it stops, forms a canopy, and waits for the startled prey to take shelter in the false refuge. Further, the bird holds its canopy for a minute or two, waiting for many tiny fish to enter the canopy before it starts to feed.

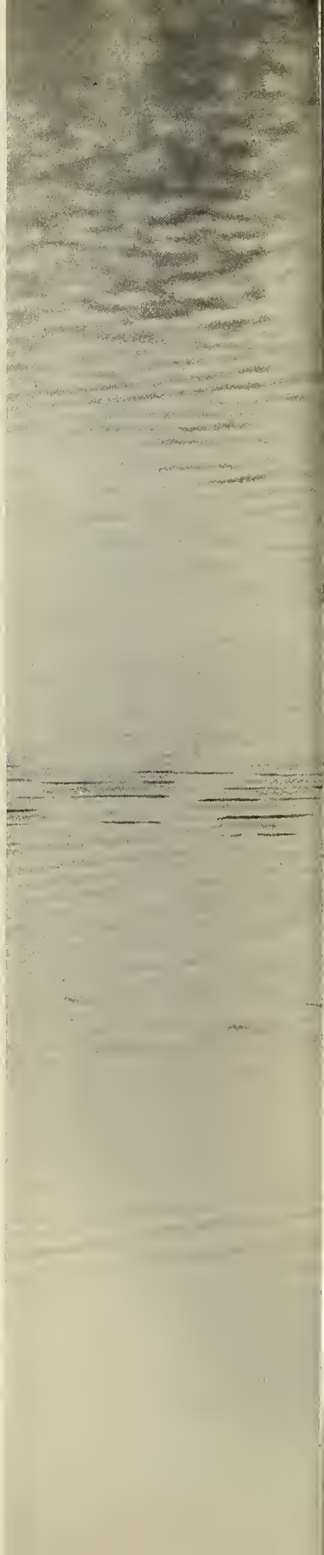
So far, in this brief view of heron feeding behavior, we have considered one possible mode of evolution beginning with wing-flicking and ending with canopy feeding. In the general category of "disturb and chase" techniques, however, herons show other methods equally interesting to us, and of survival value to the herons.

For example, the snowy egret, *Leucophoyx thula,* and other species engage in a fascinating foraging method called "foot-stirring," in which the bird actually stirs the substrate (mud, for example). Sometimes, while wading slowly forward, it extends one leg

Aerial variation of "foot-stirring" is used by snowy egret. As it flies, bird lowers a foot and stirs turtle grass or other aquatic plants to flush prey.

FEEDING REPERTOIRE of the Louisiana heron includes the method of running forward rapidly, *above*. Heron's head is held in a low, withdrawn position.

STOPPING SUDDENLY, heron strikes at its target. Having captured prey, the bird holds it scissors-fashion in bill a moment before swallowing it, *right*.



and quivers its foot on the surface of the water. Any prey disturbed by the motions of the egret's foot is quickly seized. In so agitating the water surface, the bird seems to be using its foot as a lure. The impression is bolstered by the fact that the toes of this species are a bright yellow, whereas the legs are jet black. Such a sharp color demarcation is also found in the closely related little egret, *Egretta garzetta*, of the Old World, a species that also engages in foot-stirring. It is tempting to speculate that the color pattern evolved in conjunction with the feeding behavior, but there is no experimental evidence to support this hypothesis at the moment.

An interesting aerial variant of this technique is one that I have named "hovering-stirring." Typically, the snowy egret takes flight over the shallow water, hovers over one spot, dangles a leg, stirs some aquatic debris or a tuft of vegetation until its prey darts from cover, and makes its strike while still in flight. The reddish egret also shows foot-stirring behavior, including the aerial variant, and in so doing demonstrates its grace and agility in flight. Unlike the foot motions of the snowy egret, those of the reddish egret are more of a raking or a scraping nature. Further, the reddish egret does not deliberately extend one leg in order to scrape, but instead simply vibrates its feet as it moves forward in an otherwise normal wading manner.

In all of the disturb and chase methods treated thus far the heron has acted as its own disturbing agent, but the cattle egret, *Bubulcus ibis*, associates with any organism, including man, that will act as beater for it. Indeed, cattle egrets will act as beaters for one another, as is seen in their peculiar "leapfrog" feeding (NATURAL HISTORY, August-September, 1960). Although this type of behavior is highly characteristic of the cattle egret, it is not unique to that bird. Many other species of herons will temporarily join with foraging animals, especially hoofed mammals, in order to take advantage of the larger creatures bulk in agitating prey. I might add that cattle egrets have the usual heron equipment for fish-catching and have been seen doing just that, although a diet composed of fish is unusual for the species.

Before turning to other aspects of

heron foraging. I would like to relate an amazing example of learning in relation to feeding, first seen by Hervey B. Lovell. A green heron that foraged in an area where people threw bread into the water was apparently able to associate the presence of the bread with its use by the fish as food. Lovell actually saw the green heron seize some bread, place it in the water, and wait for the fish to grasp the bait. Indeed, he saw the green heron repeatedly retrieve the bait when it began to float into unsuitable foraging areas! The green heron's use of bait is as remarkable as the use of "tools" noted in a few other bird species.

The feeding shoal in Florida Bay, mentioned at the start of this article, is an excellent area for observing interaction among various heron species as they go about the daily task of foraging. Some of the smaller keys in the bay are covered primarily with red mangroves, while the larger ones usually have a fringe of red mangroves surrounding an inner zone of black mangroves and tangled masses of saltwort. Often the keys are used by the herons as roosting and nesting sites. Typically, the water surrounding the keys of inner Florida Bay is quite shallow; shoals suitable for heron foraging may extend from one key to another, or at least reach for some distance into the waters of the bay. Such shoals may be completely covered by water or they may be fully exposed, depending on the direction and velocity of the winds.

With the exception of the cattle egret and the two species of bitterns (American bittern, *Botaurus lentiginosus,* and least bittern. *Ixobrychus exilis*), I have seen individuals of all of the heron species that normally occur in the United States feeding o these shoals, and usually numerou representatives of most of these specie are to be found. For the most part, ac cording to my observations, the di ferent species forage in somewhat re stricted parts of the total area availab to them rather than wandering abou at random over the entire region.

For example, the green heron, whic is the smallest species represented tends to restrict its feeding to the re mangroves on the periphery of th keys or to the area immediately ad jacent to this vegetation belt. I hav rarely seen a green heron leave th shelter of the mangrove prop roots i order to forage farther out on th shoals; they did so only when th water had been swept from the shoal by the winds. By contrast, the grea white and great blue herons—th largest species in the area—concen

Leg length and water depth limit herons' foraging range and size indicates rank in dominance hierarchy. Birds are

ed their activities on the tips of the als where the covering water was pest. In general, the intermediate-d species tended to distribute them-es with respect to water depth in tion to the length of their legs. In regard, green herons were physi-y more restricted in their foraging ge than were the larger species. ey could forage in sections away m the red mangroves only when the als were fully exposed. Great white rons, on the other hand, could use entire shoal up to belly depth. How-r, the depth of the water limited the ge of some species and curtailed tain feeding patterns, irrespective species. Such active techniques as en wing and underwing feeding, ich involve much running, are not ssible in the deeper water at the tips the shoals, so the basic methods of nd and wait and wade or walk slowly are characteristic of those individuals foraging in this area. In the shallows closer to the red mangroves, however, individuals of several species run the gamut of feeding methods from wing-flicking to canopy feeding.

Many heron species surmount the deep water problem, however, if food is available or in abundance there, by diving into deeper water or by hovering over such spots in pursuit of food. Such behavior is not characteristic, but is resorted to when other methods or other areas of the habitat are not productive.

What significance can we attribute to the great diversity of feeding techniques? First, each species has a repertoire of feeding methods suited to its needs: these behavior patterns, together with those structural features that allow the heron to catch fish (long bill, long legs, etc.) constitute, in part, adaptive devices needed by a heron in order to secure a minimum daily requirement of food. Further, the different species show a "preference" for certain parts of the total available foraging area — green herons among the mangrove prop roots, great white herons out in the open in deep water, for example. Such preferences are not strictly maintained but are often "violated" by one or more species. This plasticity of behavior may be a factor of extreme importance for the welfare of the species. Extensive field observation indicates, however, that herons generally do restrict their foraging to parts of the available feeding area.

Such restriction may have evolved through stiff competition in the past, with the result that the species we watch today are specialists, so to speak, not only in where they feed, but

m left: a green heron, an immature little blue heron, a ddish egret, an American egret, and a great blue heron.

also in how they feed and what methods they use. To my mind, these structural and behavioral adaptations may be looked upon as devices for avoiding competition today and in the future. For example, the illustration on pages 48-49 shows seven species at the edge of the mangroves. Each species is foraging in a different manner, with the result that they are "sharing" the available space to the benefit of all. The black-crowned night heron, ordinarily a nocturnal feeding species, feeds on occasion during the day, when the other species shown are most active, but it does so by the stand and wait method among the mangroves. The great white heron also uses this feeding method, but is farther out on the shoal and normally does not come in contact with the black-crowns. While foot-stirring, the snowy egret moves over the shallower portions of the shoal, avoiding the debris-filled edge of the mangroves and the deeper waters out in the open. The Louisiana heron, shown pirouetting, and the little blue heron, which is head-tilting, may feed in the same general zone as the snowy egret, but in their pursuit of prey they move about over a considerable range and rarely come close to another individual. The reddish egret may wade for a time, then engage in open wing feeding, or dash about among the other species, but its movements keep it from all but a brief contact with any other individual. In this way, a diversity of feeding techniques allows a concentration of individuals and species in the same area at the same time, yet each has sufficient room in which to operate. If all species fed in the same manner, close contact would lead to threats and fights, thus reducing the time available for feeding, which plays a vital part in the existence of any species.

THE yellow-crowned night heron, not shown in the illustration, resembles the black-crowned in that it forages a great deal at night—another adaptation for reducing competition for space on the foraging areas. My observations in Florida Bay indicate that when it does feed during the day, it does so largely by standing and waiting deep in the mangroves.

What about individuals of the *same* species feeding in the same area? Competition is keen in this case, because the individuals concerned have virtually the same equipment, both structural and behavioral, so their requirements are essentially identical. Here, feeding territories may be established and maintained by active defense of a large or small area, depending upon the nature of the species concerned. Each individual adopts a part of the feeding area as its own, and when an intruder of the same species appears it is promptly threatened and/or attacked, with the "owner" the victor in most encounters. In this way, individuals of the same species are spread out over suitable foraging areas.

DR. MEYERRIECKS, who is a member of the University of South Florida's Biological Sciences department, has made a specialty of heron research. He has been a frequent contributor to the pages of NATURAL HISTORY.

SUCH territories may be extremely small (in the case of the green heron) or very large (great white heron); they may be maintained for weeks or even for months (individual great blue and great white herons watched in Florida Bay), or for a few hours during the day. Such temporary territories are very common with many individuals of most of the species we have been discussing. At least one — the cattle egret — has a moving territory at times. If we accept G.K. Noble's definition of territory as "any defended area," then the side of a moving bull or cow is a true territory, for cattle egrets typically take a stance on one side of a grazing mammal and threaten and chase other cattle egrets that try to usurp the favored position. Wherever the mammal goes, so goes the egret. I might add, however, that cattle egrets will change "territories" repeatedly during the day, favoring the mammal that moves at a steady grazing pace and thus stirs up a goodly supply of egret food.

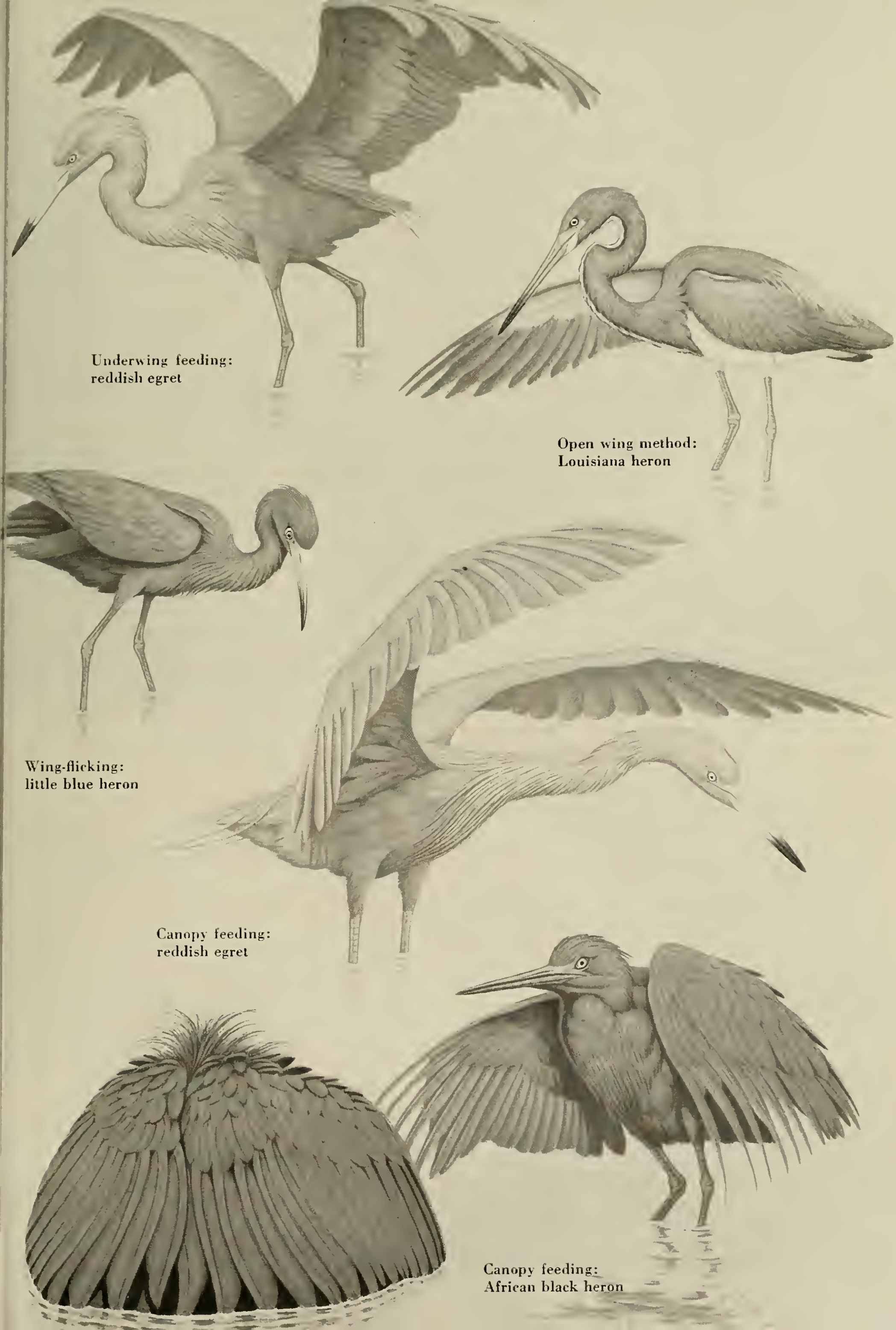
A social relationship that reduces strife between members of different species is one labeled the "dominance-subordinance" hierarchy. When it was first formulated, this concept was based on extensive data gathered from the behavioral interactions of fellow members of the same species, but the feeding herons of Florida Bay provide an interesting example of an interspecific (between species) hierarchy based largely on size. Here is a typical observation made near Cowpens Keys in inner Florida Bay. An extensive shoal is occupied by one or more individuals of the following species, in order of increasing size: green heron, snowy egret, reddish egret, and common egret. As the reddish egret dashes about the shoal, it stops, peers at the shallow water, and prepares to strike at its prey. In its erratic movements, however, it has come too close to a nearby common egret, which turns and extends its head and bill in a threatening gesture. The reddish egret flies up and lands several yards away without threatening in response. Near the reddish egret's landing spot is a snowy egret, foot-stirring; it looks up as the reddish egret lands, then turns and flies toward the edge of the red mangroves. A green heron, seeing the approach of the snowy egret, walks rapidly away from the egret's intended landing site, avoiding even a brief conflict over the foraging area.

All birds resume feeding and quiet follows for five minutes, each species engaged in its own activities. Then from its nest in the interior of a nearby key, a great white heron takes flight and sweeps the shoals clean by flying once over the feeding area, uttering a harsh "frawnk" while in flight. The other herons fly up and away from its flight path; the great white heron lands, shakes out its wings, then wades rapidly toward the deeper waters. In a matter of moments the other species land on the shoal and they commence feeding once more.

GREAT white herons demonstrate their dominant status again when the common egret comes too close during foraging activities; a brief turning of the head on the part of a great white suffices to intimidate the common egret, which withdraws without a conflict to an unoccupied part of the shoal. The function of such relationships is clear; each species "knows its place" in the hierarchy and conflict is avoided by unobtrusive withdrawal. This saves valuable foraging time.

The story does not terminate with description and speculation, for ideas must be tested and new facts must constantly be gathered to further our current meager understanding of complex interspecies relationships. The amateur ornithologist who explores heron feeding behavior may well contribute to scientific knowledge by means of his own observations and thoughts.

HERON FEEDING EVOLUTION in "disturb and chase" category begins with little blue heron's "wing-flicking," ending in African black heron's "canopy feeding."



Underwing feeding:
reddish egret

Open wing method:
Louisiana heron

Wing-flicking:
little blue heron

Canopy feeding:
reddish egret

Canopy feeding:
African black heron

CELESTIAL EVENTS

A list of astronomical occurrences for the second half of 1962

By K. L. Franklin

JULY

July 4: On this date the earth is at its farthest point from the sun for 1962—94.5 million miles.

July 17: About 3:30 a.m., PDT, the moon enters the penumbra of the earth's shadow. The time of greatest eclipse will occur nearly one and a half hours later, and the entire event will be over by 6:30 a.m. In the northeastern part of the United States, the moon will have set before this eclipse begins, and the moon will set before the eclipse ends in other parts of the country.

July 18: From 6:00 a.m., PDT, westerners should watch for the occultation of Saturn by the moon. A telescope or binocular will help observation in the morning light.

July 31: At 5:26 a.m., EDT, residents of Florida can see the beginning partial phases of an annular eclipse of the sun. An annular eclipse occurs when the moon is so far from the earth that it appears to be smaller in the sky than the sun. When an eclipse occurs at this time, the "leftover" sun is seen as an annulus, or ring, around the moon. The path across the earth from which one could observe this event starts in the Amazon jungles, crosses the Atlantic Ocean to Africa, and ends in the Indian Ocean just off the northern coast of the Malagasy Republic. An eclipse of this type has limited astronomical significance.

Saturn appears due south in the sky at midnight. Resembling a star of magnitude +0.4, the ringed planet is said to be in opposition with respect to the sun.

AUGUST

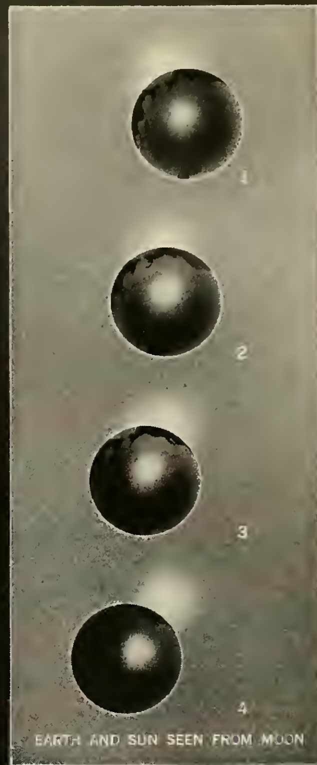
August 10-17: The mid-part of August is the time for the annual display of the meteor shower that appears to come from the constellation of Perseus. If the morning hours of August 12 were dark and clear, a single observer would be able to see about 50 meteors an hour. This rate will be severely cut, however, because the light from the nearly full moon will interfere with the numerous faint meteors and will make even the bright ones hard to see.

August 15: The third penumbral eclipse of the moon this year will not be visible in North America.

August 30: This evening, observers in the Midwest and the Rocky Mountains can see a very close approach of Venus to Spica, the brightest star in Virgo. Shortly after 10:00 p.m., EDT, the planet (magnitude −3.9) will be about one minute of arc south of the star (magnitude +1.2). In the Far West, sharp-eyed observers with telescopes may watch this event even before sunset.

August 31: Jupiter is opposite the sun, rising at sunset, appearing due south at midnight, and setting at dawn.

Viewer on moon at numbered positions in penumbra, left, would see the sun as in the sequence of images at right.



EARTH AND SUN SEEN FROM MOON

SEPTEMBER

SEPTEMBER 10: Saturn is again occulted by the moon, eginning on the West Coast about 6:30 P.M., PDT. As ie moon's shadow sweeps eastward, the local beginnings ccur later and later, until the time is after 10:45 P.M., DT, in the northeastern United States and Canada.

SEPTEMBER 23: This morning, at 8:35 A.M., EDT, spring egins in the Southern Hemisphere. Fall begins in the orthern Hemisphere at the same time.

OCTOBER

OCTOBER 8: Venus attains its greatest brilliancy in the vening sky this year: —4.3 magnitude.

OCTOBER 13: The moon is full and at perigee (closest) the earth) within a 10-hour period this morning. This ombination in such a short interval of time will result in n unusual range of tides along the seashores.

OCTOBER 22: Before dawn the planet Mercury is low in ie eastern sky and favorably placed for observation, seem-ig to be a star of —0.4 magnitude.

OCTOBER 28: For many parts of the United States, 2:00 .M. Daylight Time will become 1:00 A.M. Standard Time. 'he clock-setting formula is: Spring ahead; fall back.

NOVEMBER

No noteworthy celestial events occur during this month.

DR. FRANKLIN of THE AMERICAN MUSEUM-HAYDEN PLANETARIUM prepares this summary each six months.

THREE PENUMBRAL ECLIPSES OF THE MOON MARK 1962.

Of little astronomical value, this type of eclipse is quite unspectacular and often goes unnoticed. A total eclipse of the moon results when the moon passes into the deep shadow, or umbra, of the earth. If viewed from the moon, the sun would seem to disappear behind the earth, which would look four times larger than the sun. A partial eclipse of the moon occurs when part of the moon is in the umbra and part is in the near shadow—the penumbra. Viewed from the moon, the sun would be wholly or partially hidden, depending on the observer's selenographic location. A penumbral eclipse results when the moon is wholly in the penumbra, and the umbra does not touch the moon at all. Thus, as shown *above,* the sun would never be wholly obscured from any part of the moon turned toward it.

DECEMBER

DECEMBER 10-16: The light of the nearly full moon again interferes with attempts to view the second important meteor shower noted in this report—the Geminids. A single observer may record 50 meteors per hour in ideal conditions, and an occasional brilliant fireball will be seen.

DECEMBER 19: This morning Venus is at its brightest in the morning sky, resembling a brilliant star of magnitude —4.4, and rising about two hours before dawn.

DECEMBER 22: Winter begins in the Northern Hemisphere at 3:15 A.M., EST. The sun has reached its most southerly position as the summer begins "down under."

DESERT FORMATIONS at 12,900 feet in Antofagasta Province tower over a man and pack animals, *left*. Smoke and ash erupt, *above*, from the Láscar Volcano.

A Range of Contrast

Rare life-forms flourish at high altitudes

By LUIS M. PEÑA

THE CORDILLERA, or mountain range, of the Andes, which forms the "backbone" of the South American continent, contains the highest mountains in the Americas. Its slopes, valleys, and deserts are inhabited by many unusual insects, birds, and plants, some only recently described. One of its most precipitous and least-explored regions lies between the 22nd and 23rd parallels. In this zone the mountains include two principal ranges: the Cordillera of Domeyko on the west, called the "pre-cordilleran" Andes, and the great mountain range along the Chile-Argentina border. On the coast of this area is the city of Antofagasta in the province of the same name. From here a scientific party of which I was a member crossed the desert and went into the Andes.

The coastal mountains in Antofagasta Province rise abruptly out of the Pacific Ocean, giving a fiordlike appearance to the land's edge. They ascend over 3,000 feet, providing nesting places for various species of marine birds whose guano yields phosphate for farm fertilizer. Among the birds that nest here are the *piqueros*

Rocky soil at 12,000 feet in Andes supports plants like this *Moschopsis.*

(Sula variegata), the Peruvian booby or gannet, which nests in colonies of thousands on the projections of the precipices. Perennial vegetation consisting of cacti and other shrubs covers the crests of the mountains, deriving moisture from the mists that gather there. When rain falls on the slopes—a rare event occurring only once in a decade or two—the desert below is transformed into a temporary feeding area for herds of guanacos.

We traveled eastward through the Atacama Desert—one of the world's most arid regions—aglow with color, but where rain never falls, where the soil is nitrous, and where few living things are seen. It climbs in a smooth gradient to an altitude of 9,000 feet, and there meets the Cordillera of Domeyko, a spur of the Andes.

During the winter snow falls, and during the summer it rains in this section of the pre-cordilleran Andes, permitting the growth of a sparse perennial vegetation, which includes species of cactus of the genus *Opuntia* and other species that are virtually unknown to botanists. The variety of vegetation here is astonishing after the December and January rainy season: the plains are covered with flowers over which hover butterflies, some only recently described, as, for example, the *Hypsochila wagenknechti sulfurodice* Ureta. The most dominant of the insects are those of the Tenebrionidae (darkling beetles), characteristic of arid regions.

The Domeyko Range is the western boundary of the great salt plain of Atacama. Sheer rock walls form narrow passes that lead onto the plain, where strange, glacier-shaped saline formations extend far into the distance. Some of the formations are blackened by soil that has been carried to the plain from the northwest by storm winds. In the midst of the salt fields are lakes that support flamingos, ducks, avocets, and other birds.

Crossing the plain to its eastern edge, we came at last to the base of the Cordillera of the Andes, the dominant spine in a mountain system that extends over 4,000 miles along the west coast of South America. Here, at 8,500 feet, volcanoes—some of them active—form a backdrop for the salt plain. One is the Láscar Volcano, 19,652 feet high, a spur of which we set out to climb. In the distance we could see the Altiplano region, which is formed near the junction of Chile, Bolivia, and Argentina by the widening of the Andean system and is enclosed between two main ranges—the volcanic Western Cordillera and the Eastern Cordillera.

Following the strands of the eroded cordillera, we encountered the area's last inhabitants—Indians who subsist by cultivating wheat, corn, and other foods, and who breed llamas on the little flatland pastures. Here we had entered the *puna*, a zone rising from 10,000 to 13,000 feet, characterized by extreme temperatures and vividly associated with altitude sickness. The term *puna* refers both to the region and to the headaches and nausea experienced by many persons who climb

Road is the only sign of man's presence in the Atacama Desert in Chile, where lack of rainfall and nitrous soil severely limit life. This area is separated from Puna de Atacama, a highland counterpart, by Cordillera of Domeyko.

Chilean entomologist and authority
Andean biota, SR. PEÑA is field
ociate at Yale's Peabody Museum.

his altitude. In some the reaction vere enough to force their return ie lower levels.

ur party arrived in the *puna* in uary. The rains had begun, and ms of water ran in canals of com- vegetation formed of the spiny *Oxychloe andina*. Underneath s submerged in gullies, we found optera of the family Elmidae, y Plecoptera (stoneflies), and e naiads of Ephemeroptera (may-). The soil in this area is composed olcanic sand. The dominant plant he *tola (Baccharis tola)*, which the name *tolar* to the extensive and arid hills. On its stems we found a rare species of long- ned beetle, some weevils, and some -unidentified larvae. Under rocks edded among the *tola* were ground les, road beetles, weevils, and ny species of darkling beetles that e unknown to us.

limbing still higher through this on of rolling hills, we traveled th toward an area characterized by *on*, a hardy yellow grass of the us *Stipa*. Here, too, are butterflies of the family Satyridae, such as *Faunula eleates* Weymer, and some unknown species, possibly of the genus *Argyrophorous*, to judge by the spots of silver on the upper surfaces of their brown wings. We succeeded in capturing some specimens, an exhausting task at such altitudes. Lycaenidae, or gossamer-winged butterflies also hovered among the rocks, many of which were covered by a hard, compact, almost mosslike plant, known as *Laretia compacta*. It is composed of hundreds of tiny rosettes, and when in bloom is visited by various insects, notably bee flies (Bombyliidae).

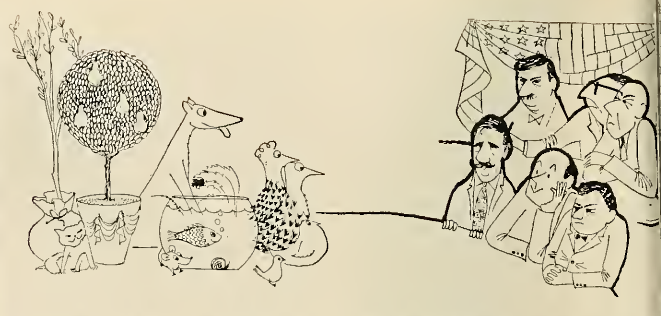
The particular spur of the Láscar Volcano that we were climbing opened into a pass with a view of surrounding volcanoes, among them the Hecar, the Laguna Verde, the Tumiza and the cone of Paniri. We stood higher than 15,000 feet in an area of high-velocity winds and scant vegetation.

HERE small blue butterflies were battered by the wind. Some managed to fly, but others hugged the ground with wings outspread to avoid being blown away. We also saw white butterflies *(Piercolias)* as well as a tiny ash-yellow butterfly *(Pyrgus barrosi* Ureta). But we were most interested in a Pieridae (*Hypsochila peñai* Ureta), one of the strangest of the Andean butterflies, in that it lives at extreme altitudes. It is white with mother-of-pearl spots, and visits one of the few large-flowered annual plants in these regions, the *Perezia atacamensis*, where its larva probably develops.

In the distance lay the salt depression where flamingos breed. Multicolored lakes dotted the plains that sloped toward Argentina. Behind us lay the desert. This view from the pass allowed us to encompass, at least in part, the awesome vastness and the astonishing diversity of the Andes.

SHARP SPINES on leaves distinguish alpine plants of the family Loasaceae.

AMAS ARE BRED by Indians who live in the *puna* region the Andes. Animals are in scrub area overlooking the great salt plain of Atacama, bounded on the west by the Cordillera of Domeyko and on the east by the Andes Range.



WASHINGTON NEWSLETTER

By Paul Mason Tilden

In June, 1958, the 85th Congress passed Senate bill 846, an act to create a study group now known as the Outdoor Recreation Resources Review Commission. The task charged to the commission was a formidable one. It was, in the words of the enabling act, "to inventory and evaluate the outdoor recreation resources and opportunities of the nation . . ." both present and future.

What, Congress asked the commission to learn, are the recreational needs and means in America today? What will they be in 1976? What in the year 2000 when, the graphs say, we shall be 360 millions?

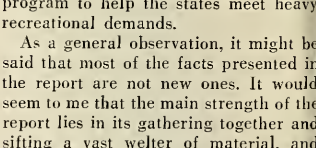
In accordance with Congressional instructions, the commission—a distinguished group of eight Congressmen and seven citizens "known to be informed" in the fields of preservation and outdoor recreation—presented its answers on the last day of January, 1962. The summary of the commission's work is now available in a 246-page, illustrated publication entitled *Outdoor Recreation for America*. It may be obtained for $2.00, postpaid, from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

In the space available here, it is possible only to point to those findings of the commission that seem crucial, and to offer brief comment on the recommendations. Of prime importance in future outdoor recreation planning, it would seem, is the report's developed fact that by the year 2000 some three-quarters of the nation's people will live in urban centers where land-use competition is keenest; where recreation needs are greatest; and where recreational opportunities are the farthest removed. It seems implied here that future land-use projects—highway construction, water resources development with its dams and reservoirs, and the like — must be planned with an eye toward recreational needs. Maximum utilization would seem to be the key phrase.

A second important point developed by the report is the problem of evaluating a non-commodity such as recreation. What is a Sunday picnic with the family or a trip to the Grand Canyon really worth? In searching for an answer to questions like these, the commission found little useful information from which it could draw, but if the need for outdoor recreation is to be made competitive with tangibles like superhighways and city water supplies, some solid research seems to be indicated.

The recommendations of the study were, in essence: the promulgation and implementation of a national outdoor recreation policy; the adoption by outdoor recreation agencies of a land classification system to insure the best use of recreational resources; long-range planning at both Federal and state levels for future recreational needs; establishment of a Bureau of Outdoor Recreation in the Department of the Interior to coordinate Federal and state recreational programs; and a Federal grants-in-aid program to help the states meet heavy recreational demands.

As a general observation, it might be said that most of the facts presented in the report are not new ones. It would seem to me that the main strength of the report lies in its gathering together and sifting a vast welter of material, and reducing it into an orderly foundation for legislation in the field of parks, preservations, and mass outdoor recreation.



The President and Conservation

Hard on the heels of the ORRRC report came a presidential message to Congress presenting the administration's views both as to needed legislation and as to contemplated executive

ions in the broad field of conservation. President Kennedy announced that at a yet-unspecified time during 1962 he would convene a White House Confer-e on Conservation, at which time servationists would be invited to ex-nge views with the administration on eded future efforts in the field. In re-ct to outdoor recreation and the na-nal need for additional parklands and en spaces, the President drew heavily m the recommendations of the Out-or Recreation Resources Review Com-ssion; as foreseen above, he used its port as the basis for some proposed ure legislation.

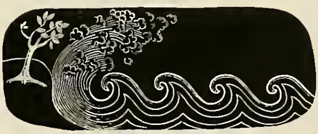
n actions possible at the executive el, Mr. Kennedy promised the ap-ntment of an Outdoor Recreation Ad-ory Council from among the chiefs the numerous Federal agencies that , by virtue of jurisdiction over pub-lands, more or less involved in the door recreation business. Also fore-dowed by the President was the ation of the ORRRC's recommended reau of Outdoor Recreation in the De-rtment of the Interior, to function as co-ordinating and "action" agency the implementation of governmental door recreation policies.

At the Congressional level, the Pres-nt served notice that the administra-n would press for legislation estab-hing a program of matching grants state outdoor recreational programs; o urged was amendment of the pres-Federal surplus property disposal v, to allow state and local govern-nts better terms in acquiring Federal ds for park and recreation purposes.

Particularly important to conserva-nists was the President's request for islation to establish a "Land Con-vation Fund," which might serve as a ancial reservoir against which funds uld be drawn for immediate land ac-isition as new parks or recreation eas were authorized by the Congress. ch a ready fund, conservationists felt, uld be instrumental in nailing down sirable parklands while acquisition sts were reasonable, avoiding the lag tween authorization and actual land quisition and its accompanying specu-ive land development. As seen by the esident, the Fund would be brought immediate life through a Congres-nal advance of a half-billion dollars yable over the next eight years; the nd would later repay the Treasury d continue to function through receipt recreational area entrance, or user s (like those presently collected in a v units of the national park system) d through income from several rela-ely minor tax sources.

The President noted heartening prog-ss in the struggle against the pollu-n that has so disgraced the nation's eams and waterways, and he again edged the administration to "full development" of the national water resource "for all purposes." (In the phrase "full development," some conservationists felt, lay the seeds of future contention between the "preservation" and "conservation" factions of the over-all conservation camp: to some, the words presaged more bitter fights like that of the Echo Park Dam in Dinosaur National Monument, or the current struggle over protection of Rainbow Bridge Monument; each was triggered by threat of national parklands invasion by dams or reservoir waters.)

Mr. Kennedy urged Congress to pass his Water Resources Planning Act, introduced for him in the Senate by Clinton P. Anderson of New Mexico during the first session of the 87th Congress. This act would authorize Federal assistance to states for water resource planning and establish a Water Resources Council to co-ordinate river basin planning and development within governmental agencies. He also touched briefly on the need for technological research and sound planning in the fields of mineral and timber resources; in respect to the latter, he indicated he would ask for legislation accelerating development of multiple-use forest trails and roads.



Struggle at Kinzua

A long and rather obscure struggle in which conservationists have been able to contribute little but sympathy for the underdog has been that between the U.S. Army Corps of Engineers and the Seneca Nation of Indians.

Back in 1938, Congress authorized a flood control scheme for the Ohio River Basin; one unit of the scheme was a dam and reservoir on the Allegheny River at Kinzua, not far from the New York state line in northwestern Pennsylvania. Although construction has been long delayed, within recent months the Corps has started to move earth on the project.

A substantial percentage of the lands to be inundated by the 23,000-acre Kinzua Reservoir, however, is the property of the Seneca Indians—land guaranteed to them by the Pickering treaty of 1794. (Timothy Pickering was George Washington's deputy in the negotiations.) The Senecas quite understandably do not want to leave either their ancestral lands or their farms.

Several incentives have been offered to the Senecas by the Government in an attempt to smooth the matter — money from land condemnation proceedings, and aid in finding lands on which to relocate. The Indians indicate they want

neither. "The land is your mother," they say. "You do not sell your mother."

The Senecas have hired engineering talent to work out alternative flood control schemes, but these have been rejected by the Corps for one reason or another. They have instituted court actions, including an appeal to the Supreme Court, but to no avail. They have appealed to the President, but the President has declined to act in the matter. Barring a miracle, Timothy Pickering's treaty with the Senecas will be buried in the earth and concrete of the Kinzua Dam. Conservationists are sorry; the Senecas are sorry; everyone seems sorry; but the bulldozers continue to grunt and shove. The dam is scheduled for completion in 1965.

Golden Eagle Protection

Accounts of uncontrolled slaughter of the golden eagle that have appeared in the public press during the past several years have apparently caught the attention of many Americans both in and out of conservation circles. Ornithologists have expressed the view that the golden eagle cannot last indefinitely in this country under the massed guns of eagle hunters, who have actually taken to the air in their pursuit of the big bird. Bird students have also pointed out the strong probability that many bald eagles, presently protected by law, have been killed by mistake, since for the first three years of the bald eagle's life it is almost indistinguishable in appearance from the mature golden eagle.

In some of the Southwestern states, notably in Texas, airborne hunters collect a bounty from ranchers for killing the birds, then sell the feathers to the Indian artifacts industry for making "Indian headdresses" for the tourist trade.

Public indignation over the slaughter of the golden eagle, whose only weakness apparently is an occasional hankering for spring lamb, has made itself felt in Congress. In the upper chamber, Senator Yarborough of Texas has introduced legislation—for himself and three other Senators—for complete protection of the golden eagle, while in the House four separate resolutions of similar tenor have appeared. Of these latter, the resolution introduced by Representative Conte of Massachusetts has been the most active, having been called up for hearings by an appropriate subcommittee during February of 1962. The substance of all the proposals: to amend the language of an act passed in 1940 for protection of the bald eagle to include the golden eagle within its scope.

Hunting in the Parks

One of the worrisome problems that the National Park Service has had to deal with in the past several years concerns the management of wildlife in the parks and monuments where the wildlife, especially the ungulates, has overreached the carrying capacity of its range and has upset the natural picture that the Service is charged with presenting to the public. Contributing to the problem has been the virtual extinction, in most great parks and monuments, of the natural predator population.

The need for eliminating surplus mammals has always been difficult to explain to much of the park-going public, and the picture has been even further blurred during the recent past by strong pressure from state fish and game commissions and hunter organizations for public participation in mammal reduction programs. It has been urged, rather transparently, that hunters should be allowed to help "harvest" surplus animals—indeed, it has even been suggested that hunters have a duty in this direction.

Most conservationists and many scientists have roundly opposed the opening of the parks to public hunting under any guise. During the latter part of 1961, National Park Service Director Conrad L. Wirth issued a Service statement of policy that in effect thanked the fish and game commissions and the hunters for their great interest in the mammal population control problem, but respectfully declined the proffered assistance. "Recreational hunting, however well justified and appropriate in other places," said Director Wirth, "is irreconcilable to national park and national monument purposes." With this, most conservationists heartily agreed. They knew, however, that the Director's forthright words might not be the last heard on the subject. This was a policy statement that needed confirmation or rejection by the Secretary of the Interior. Six months after the policy was set forth by Director Wirth, Secretary Stewart L. Udall had given no indication of his feelings in the matter. Conservationists are still worried.

Erratum: The May issue of this magazine contained a typographical error in the chart of elements on page 36. The half-life of carbon-14 is 5,600 years, not the 5,600 million years that was shown.

This list details the photographer, artist, or other source of illustration, by page.

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28-41—Lee Boltin, except 32—AMNH
43—Mt. Stromlo Observatory
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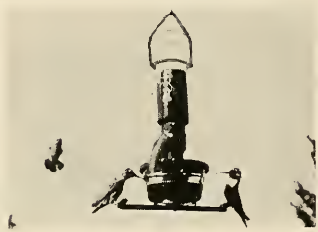
46-47—Sky Map, after Henry M. Neely
48-49—Guy Tudor
50-51—Robert Meyerriecks
52-53—Guy Tudor
54-55—Robert Meyerriecks
56-59—Guy Tudor
60-61—Helmut Wimmer
62-65—Luis E. Peña
66—AMNH



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COVER: A Portuguese man-of-war, *Physalia*, trails its tentacles as it floats of the Florida Keys. The gas sac that supports *Physalia* may be blue, as shown or be peacock-green at the base, and it may have a pinkish crest. Sometime a man-of-war is found with a milky-white sac instead of a blue one. The gas sa itself is movable, and men-of-war have been observed to rock the floats fron side to side at regular intervals to keep the membranes wet. Dr. Werner Jacob discusses *Physalia* and other members of the group Siphonophora in the articl that begins on page 22. The photograph on the cover was made by David Linton.

The American Museum is open to the public without charge every day during the year. Your support, through membership and contributions, helps make this possible. The Museum is equally in need of support for all of its work in the fields of research, education, and exhibition.

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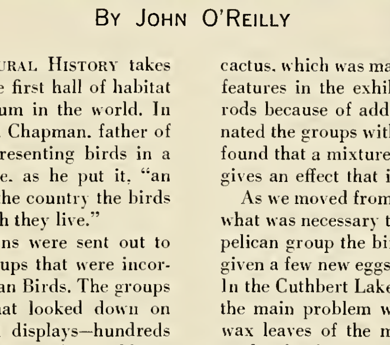
MUSEUM MEMO

By John O'Reilly

The American Museum of Natural History takes deep pride in the possession of the first hall of habitat roups to be displayed by any museum in the world. In he last century, the late Dr. Frank M. Chapman, father of he habitat group, had the idea of presenting birds in a egment of their environment to give, as he put it, "an dequate conception of the nature of the country the birds nhabit and the conditions under which they live."

Between 1898 and 1910, expeditions were sent out to ollect material for thirty habitat groups that were incororated into the Hall of North American Birds. The groups vere arranged around a balcony that looked down on xamples of the Museum's first bird displays—hundreds of cases in which specimens stood like rows of toy soldiers.

Recently, when it came time to renovate the hall, it was ound that more than two-thirds of these original groups, ll of which are more than fifty years old, could be retained with only a general cleaning and face lifting. The other lay Dr. Dean Amadon, Chairman of the Department of Ornithology, ook me on a tour of work in progress to show how Museum preparators do a job of scientific house cleaning. We were joined by George E. Petersen, technical supervisor in the Exhibition Department.



Dr. Chapman had planned well for an enduring exhibit, selecting large birds such as the California condor and the pelican, which are less fragile than small birds such as warblers or sparrows. Dr. Amadon said that in many of the groups it was necessary only to remove the birds, give them a thorough cleaning, touch up the backgrounds, fumigate the interior, and close up the cases again. All groups must be disinfected to prevent the ravages of tiny beetles and other vermin that share man's environment.

Pausing before the refurbished duck hawk group, Dr. Amadon said, "You'd think that bird was mounted yesterday." Old wax leaves, some of which had curled, were removed from groups that contained leafy plants and were replaced with plastic leaves that are lighter, more translucent, and can be attached to natural terminal branches, which are preserved with glycerine and formaldehyde.

New sand was sent from Arizona for the desert group, and new cactus plants were carved from balsa wood to which natural spines were attached. Even the large cholla cactus, which was made of wax and is one of the dominating features in the exhibit, had to be strengthened with iron rods because of added lights. In the old days they illuminated the groups with incandescent bulbs. Today they have found that a mixture of fluorescent and incandescent lights gives an effect that is considerably more natural.

As we moved from group to group the two men described what was necessary to put them in good shape. In the white pelican group the birds first were cleaned. They were then given a few new eggs and the background was scrubbed up. In the Cuthbert Lake setting of the Florida rookery group, the main problem was with greenery. Over the years the wax leaves of the mangroves had curled, so molds were made of a few, and new leaves were fashioned in plastic.

A few of the groups were entirely replaced. One of these was a beat-up group of brown pelicans that had not stood the test of time as well as some of the other specimens. In its place will be a magnificent bald eagle group, depicting a scene on the Chilkat River, in Alaska, where, in November, as many as 2,000 eagles can be seen along a ten-mile stretch when the salmon are dying after spawning. In this group a young bald eagle with a seventy-eight-inch wingspread seems to be flying right at the visitor.

A thorough job of scientific house cleaning takes long hours of meticulous work. The task, which has gone on for months, is almost finished, and soon the hall will open.

Visitors are sure to find many groups of special interest that will be brighter and more realistic than when they were created. For example, the fight to save the remnant of the great race of whooping cranes has caused international concern in recent years. In the Museum's exhibit, a pair of whoopers are displayed as they once lived on the Minnesota marshes. Another group shows the rich bird life that existed on the Hackensack Meadows, across the Hudson from the Museum. In writing of this group, Dr. Chapman said: "With the so-called 'march of civilization,' all this wealth of bird and plant life is bound to disappear, to be replaced by railways, factories and docks."

Any commuter crossing the polluted and begrimed Hackensack Meadows today can recognize the grim fulfillment of that prophesy, but Dr. Chapman's group is still with us as a reminder of the natural beauty that once existed there.

Reviews

Books help "beachcombers" play the "shell game"

By Ruth D. Turner

A Field Guide to the Shells of our Atlantic and Gulf Coasts, by Percy A. Morris. *Houghton Mifflin Co., $4.50; 236 pp.* How to Know the American Marine Shells, by R. Tucker Abbott. *Signet Key Books, $.75; 222 pp.* Caribbean Seashells, by Germaine L. Warmke and R. Tucker Abbott. *Livingston Publishing Co., $8.95; 346 pp.* Sea Treasure, by Kathleen Yerger Johnstone. *Houghton Mifflin Co., $4.00; 242 pp.* Shells are Where You Find Them, by Elizabeth Clemons. *Alfred A. Knopf, $2.75; 86 pp.* Shells, by Roderick Cameron. *G. P. Putnam's Sons, $3.95; 128 pp.* Sea Shells of Tropical West America, by A. Myra Keen. *Stanford Univ. Press, $12.50; 624 pp.* Panamic-Pacific Pelecypoda, by Axel A. Olsson. *Paleontological Research Institute, $15.00; 574 pp.* Molluscs, by J. E. Morton. *Harper Torch Book, $1.40; 232 pp.*

Shells, because of their beauty of form and color and their durability, hold a fascination for people of all types, and satisfy the innate collecting instinct in most of us. They have been used throughout the ages by both primitive and civilized man for food and adornment; they have provided motifs in art and architecture; they are still used as currency among primitive tribes, such as those in New Guinea. Collecting shells and building private collections became popular as early as 1670, when Buonanni wrote his book entitled *Recreatio Mentis et Oculi in Observatione Animalium Testaceorum*, and, in 1688, Martin Lister published his magnificent scientific volumes *Historia sive Synopsis Methodica Conchyliorum*. During the days of discovery, when sailors returned to Europe from far-off places, it was popular to build up cabinets of natural objects, especially shells. These collections became a mark of learning, wealth, and position. Since that time there have been periods of great collecting activity and of depression when relatively little was done.

Just what factors were most important in producing the current peak of interest in shells is difficult to say. In this country, where the enthusiasm is the greatest, it is probably that collecting is possible in a wide variety of places through the increase of leisure time, plus wider air and automobile travel. Caus and effects are often difficult to separa Many people have developed an enth siasm through reading, and have th gone to the field to collect. In turn, t existence of people interested in a pa ticular area has often created a ne and demand for books on the subje Unfortunately, the results are not alwa good, and a series of fair to poor boo about mollusks have been selling simp because they have been the only on generally available.

Today there are more collectors an malacologists than have ever existed. A the present time there are in the Unite States twenty-four shell clubs, whos combined memberships reach into th thousands. Many of them hold annu shell fairs; even shell auctions, whic were popular in the 1800's, are agai being held. A bibliography of the book on mollusks published within the pa twenty years would be amazing in i size and variety of treatment.

It is true that most amateur shell co lectors are interested in marine mo lusks, and most of the books discusse here are concerned with them. It is als true that some collectors are unawar that mollusks live on land and in fres water; that many have never seen them and that even fewer have collected them This is unfortunate, because land an fresh-water shells can be just as interest ing as those that live in the sea.

Inexpensive books on local faunas hav been lacking. Consequently, it is a tru pleasure to see two such excellent book as a *Handbook of the Gastropods o Kansas* by A. B. Leonard, and *Shells o the New York City Area* by M. K. Jacob son and W. K. Emerson published t fulfill needs of special collectors. Bot these books are highly recommended.

The well-known Peterson Field Guide Series has produced a book covering a larger geographic area—*A Field Guide to the Shells of our Atlantic and Gul Coasts*. This small volume is readily carried in the pocket and, because it is inexpensive, one is not afraid to use it at the seashore. Identifying material in the field, especially when a collector is a beginner, adds greatly to the fun and often increases the number of species found. If an experienced collector is

t available to go shelling with the ophyte. the next best thing is a pocket iide. and this is one of the finest on the ırket for the area covered. Over 500 mmon western Atlantic species are scribed and figured. many of them in lor. Closely related species are genally grouped on the same plate, and e brief diagnostic phrases given on e plate captions are an aid to identifition. The classification chart, showing e relationship of the mollusks from ıylum to subspecies, will be helpful the beginner who lacks a background biology. The brief glossary of terms ıd the notes on how to care for the colcted material will also prove useful.

Perhaps the best buy for the beginner ho has not progressed far enough to ant to invest even a dollar in shell ooks is the little seventy-five cent paperıck. *How to Know the American Marine Shells* by R. Tucker Abbott. This is ıother pocket field guide packed with formation. It deals with the most comon species of both the Atlantic and acific coasts of the United States and anada. and has brief descriptions of oout 400 species. most of which are lustrated in black and white or color. is a concise guide to where. how. and hat to collect; how to care for a collecon: how to form a shell club. It even ıcludes a digest of the shellfishery laws f the various states. The enthusiastic eginner will soon graduate to the same uthor's previously published *American Seashells*, a much larger book, which is oncerned with the same area but covers ıore species in greater detail.

Germaine Warmke, now Curator of Iollusks at the Institute of Marine Bilogy in Mayagüez, Puerto Rico, became ıterested in shells as a hobby when she ıoved to that delightful island. *American Seashells* was her guide, but she oon found that there were many species ı Puerto Rican waters that were not decribed in easily available literature. he collected avidly and began making otes and lists of these additional speies. The result was a book with emphais on Puerto Rico. *Caribbean Seashells* ıy G. Warmke and R. T. Abbott. Although the accounts are not complete, ınd the really experienced collector. amiliar with the area, might find points o criticize. the book is intended for the ıewcomer to the Caribbean and has nany helpful hints on how to collect in he tropics and to ship material home. There is even a brief Spanish lesson, iving pertinent words and phrases for he shell collector. The book has a careully selected bibliography and fortyour plates of photographs.

Dr. Turner is a malacologist and a member of the staff of the Museum of Comparative Zoology at Harvard.

For the beginner who still does not quite understand why people become so interested in shells, for the husbands or wives who tolerate the activities of their "shell-shocked" mates, or for anyone who wants to enjoy a delightful philosophical approach to the "shell game," Kathleen Johnstone's *Sea Treasure* is recommended. Mrs. Johnstone is an ardent shell collector with a flair for writing and an understanding of the importance of the role of the amateur in this field, and she bridges the gap between the museum curator and the amateur collector, to the benefit of both. While discussing the various methods of cleaning, labeling, and storing shells, she cleverly interweaves a discussion of the reasons for collecting, the satisfaction obtained from various types of collections, and the contributions hobbyists can make to the science of malacology. This is not a book to be used for the identification of shells, but the chapters entitled "Shells Belong to the Animal Kingdom," "The Animals That Live Inside Pelecypods," and "The Animals That Live Inside Gastropods," explain many of the more interesting facts about mollusks as living creatures. Although Mrs. Johnstone is not a biologist, her account is remarkably accurate. This is a book to read and enjoy, and is also one to return to for many helpful hints.

Shells Are Where You Find Them, by Elizabeth Clemons, is a book for children. Its unusual pen-and-ink illustrations are artistic and for the most part accurate. The brief and simply written text, printed in large, readable type, explains just enough about the kinds of mollusks and where they can be found to interest but not to tire a youngster. The introductory remarks on collecting and caring for a shell collection are presented in a way that can be understood without the aid of an adult, but the whole family might find themselves joining a shell search. Only the three major classes of mollusks—the gastropods, bivalves, and chitons—are discussed, and about 150 species are pictured.

Roderick Cameron's *Shells* is an unusual book. The author is obviously interested in shells and shell collections from the historic viewpoint. He gives a brief, interesting account of the uses of shells in art and architecture, and includes a colored illustration of the fantastic shell pavilion at Goodwood Park, Sussex, England, which was completed in 1739. Pictures of Tradescant, Ashmole, Dampier, Sloane, Rumphius, and Linnaeus, and of two early museums accompany the story of shell collections and the development of conchology in Europe. Many of the books that were published from the 1600's to the Victorian era are discussed, and many of the illustrations from these historic works are reproduced. This section is worth

reading, especially by the amateur w[ho] has been forced to struggle throu[gh] synonymies and technical discussions [of] nomenclature in scientific reports. T[he] biological portion of the book, howeve[r,] is so filled with errors that it is frighte[n]ing. Unfortunately, the chapters [on] "Univalves and Bivalves," "Interesti[ng] Shells," and "The Barrier Reef" conta[in] many interesting historical reference[s,] but the reader must be able to separa[te] fact from "fiction." On the book jack[et] Mr. Cameron is described as a specialis[t,] which leads one to believe he must be [a] historian—he is not a malacologist.

The books so far discussed here hav[e] been strictly in the "popular" categor[y.] There are others that fit into both th[e] advanced-popular and the scientific, [or] technical, class. If they are well illu[s]trated, these are also of interest to th[e] amateur shell collector, so a few of the[m] are included here. The best example [of] this type is *Sea Shells of Tropical We[st] America* by Dr. Myra Keen. This boo[k,] published in 1958, is the result of a nee[d] for a comprehensive account of the mo[l]lusks of the Panamic Province—the sea[] shore that extends from the Gulf [of] California to Colombia. Because of it[s] scientific treatment, the book is on[e] every malacologist will welcome, an[d] because it is written in non-technica[l] language it will be equally sought afte[r] by amateurs. For the first time, one boo[k] describes 1,650 species, and more tha[n] 1,500 of them are illustrated. This cover[s] most of the species over one-fifth of a[n] inch in length. The brief diagnostic de[]scriptions are in juxtaposition to th[e] figures, allowing ready comparison o[f] the text with the fine illustrations. The appendixes include a most useful series of "Keys to the Major Pelecypod and Gastropod Divisions," with which one can place an unknown shell in the proper family. Then, by using the keys to the genera and subgenera, which are included under each family in the main portion of the book, one can quickly and systematically determine the species.

Recently, another publication has appeared to add to our knowledge of the Panamic fauna. The *Panamic-Pacific Pelecypoda* by Axel A. Olsson, is a scientific, monographic treatment of the bivalves of the area that extends from Panama to Peru. However, it is a book that the serious collector will find helpful and interesting. It is probably the most complete treatment ever attempted of the bivalves of such an extensive area. Although the descriptions are written in technical language and most of the comparisons of closely related species are expressed in keys, the excellent illustrations are sufficient in most cases to permit identification of material without reference to the text. Eighty-six plates illustrate the inner and outer surfaces of the valves of each species and, where

·cessary, enlarged sections show sculp-re and hinge structure details. The cality records and ecological notes ven for each species—most of them the sult of Mr. Olsson's long experience the area—will be helpful to anyone anning to visit these rich collecting ·ounds. The estimated number of spe-es of shelled mollusks for the Panamic-acific Province is given as 2,200. Of ese, only 496 are pelecypods, and an nazing proportion (30 genera and sub-enera and 74 species) are called new.

THE serious amateur, as well as the student of mollusks, should be as iterested in the anatomy and function-ıg of mollusks as in their shells. In fact, nowing how the various types of mol-isks feed, how they "breathe," what ·pe of sensory organs they have, and ow they reproduce adds interest and ften aids in finding specimens in the eld. Dr. J. E. Morton's *Molluscs* is the nly recent English-language book on ıe form and function of mollusks. In ıe early chapters, following a review f the general features of the Mollusca, r. Morton discusses the external form nd function of the six classes, using iagrammatic sketches to emphasize im-ortant points. In the subsequent chap-ers, such as the "Mantle Cavity and ;ills," "Feeding and Digestion," "Ner-ous System, Sense Organs and Beha-ior," and "Sex and Reproduction," first he general features and then the devia-ions exhibited by the various groups are onsidered. Throughout the book, Dr. Morton develops the theme of evolution vithin the phylum and relates the hanges that have occurred in the ani-nal's functions and adaptation to its ·nvironment. A carefully selected bibli-ɔgraphy documents all statements. Al-hough first published in England, this ɔook has been so popular with both ;eneral biologists and mollusk special-sts that this paperback edition is now ıvailable in the United States.

In concluding this review it should be ɔointed out that many popular books ıave recently been published in other ·ountries. Among these are *Shells of the Australian Sea-Shore*, by D. F. Mc-Michael, *Coquillages Marins*, by J. Ar-·ecgros, which deals with the shells of the Atlantic and Mediterranean coasts of France, *Shelpen*, by Bob Entrop, on the shells of the Netherlands, *A Begin-ner's Guide to South African Shells*, by K. H. Barnard, and the exquisitely illus-trated *Encyclopedia of Japanese Shells* by Okada. All of these are illustrated and the plate captions give the scientific names, so it does not matter in what language they are written—it is easy to determine their contents.

As with any hobby, shell collecting becomes increasingly interesting as more and more is learned about this subject.

IN BRIEF

THE SEA, by Leonard Engel. *Time, Inc., $3.95; 190 pp., illus.* THE FOREST, by Peter Farb. *Time, Inc., $3.95; 192 pp., illus.* THE DESERT, by A. Starker Leopold. *Time, Inc., $3.95; 191 pp., illus.* THE MOUNTAINS, by Lorus J. and Margery Milne. *Time, Inc., $3.95; 192 pp.*

THE problem facing the editors of the "Life Nature Library" is the correlation of two mediums—book and picture magazine. *The Sea, The Forest, The Desert,* and *The Mountains,* four examples from *Life's* editors, are attractive, and in some ways provide good summaries of their material, but all suffer from the difficulty of juxtaposing pictures and text. The photographs are usually striking, in some instances, spectacular, but they have a way of making a barrier of themselves by standing in the path of explanation or simply changing the route suddenly so that the reader, now a viewer, finds himself in different country without a guide.

The Desert is characterized by eye-catching photographs, some of the best that money can buy. A. Starker Leopold has written a competent, interesting text and the book is full of up-to-date information on one of the earth's most fascinating environments. The volume is surely well worth owning and yet its method, which is essentially encyclopedic, results in the presentation of rather too much material for the limited space assigned to it.

The Mountains is an attempt to rectify the fact that much of our knowledge of mountains is of recent origin and has not been widely disseminated to the layman. This handsomely illustrated book presents a brief but understandable résumé of the geography of mountains, the concepts of mountain evolution, the dynamics of volcanoes, the ecology of mountain vegetation and animal life, the unusual biology of mountain-dwelling peoples, and the adventurous story of men and women (and dogs) who have striven to conquer the highest, most inaccessible mountain peaks known.

Because both the Milnes are professional biologists, it seems strange that the most serious errors in this volume —and there are a number—are to be found in the sections dealing with biology. The chapter, "Planets, Winds, and Ice," abounds with anthropomorphic and teleologic statements, as well as a variety of factual errors. The book is worth its price. Not every statement it con

tains, however, should be accepted uncritically by the reader.

The Sea suffers by comparison with *The Forest*. The latter is written in a disciplined and competent style, while the former abounds in hasty generalizations and abrupt conclusions. As a result, more is learned of the forest than of the sea. Both books hold much (probably too much) to attract the eye, but the exactions of the picture and caption technique cut down on verbal expression. In future, the editors may be able to strike a better balance if they decide what sort of books they are producing.

THE OSAGES, by John Joseph Mathews. *Univ. of Oklahoma Press, $7.95; 826 pp.*

THIS book represents a noteworthy addition to the interpretation of Indian civilization, and although it contains over 800 pages, the length should not discourage anyone interested in the heritage of their native land—particularly when one considers that the author, John Joseph Mathews, is an Osage.

The Osages attempts to interpret and recount the cultural history of this Indian nation in terms of its own symbolism, ritual, and language, insofar as translation is possible. We are a long way from understanding the identification of a Neolithic people with natural forces. These people found their way by means of "the moss, the lichen, the stars, and the sun. . . ."

The symbolic culture of the Osages was far from "primitive" or "simple" as we are inclined to use those terms, but complex, precise, and beautiful in many ways. Because the author writes knowingly about the Osages, he accepts the authority of their religion and succeeds in making their decline and fall at the hands of the next "Americans" even more dramatic. The contrast between our two civilizations is sharply drawn, but the distinct impression remains that culturally the Osages were never totally crushed, and that their wild, ancient relation to the natural world remains relevant and unsullied. This is an exceptionally interesting and useful history.

NATURE ON THE RAMPAGE, by Ann and Myron Sutton. *J. B. Lippincott Co., $6.00; 328 pp.*

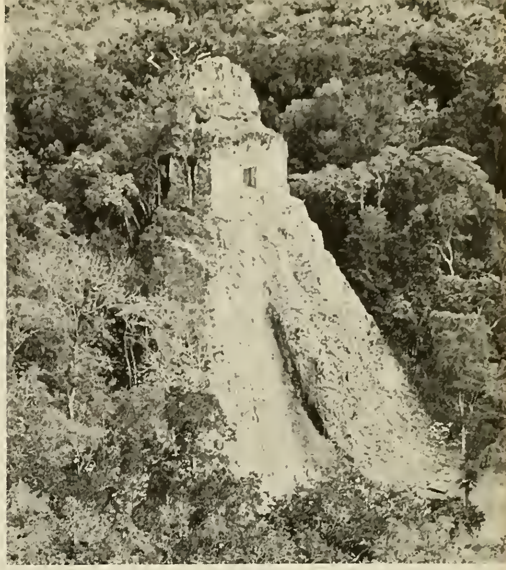
TO one who has always enjoyed nature's rambunctiousness, *Nature on the Rampage* is a disappointment. The rampages are listed by chapter headings but, unfortunately, they are not well chosen. For instance, chapters two, three, and four are titled "Winds," "Hurricanes," and "Tornadoes," respectively. "Rain," "Hail," and "Lightning" are the titles of three more chapters, and one gets confused as to whether the particularly heavy rains encountered in the last-mentioned chapter are associated with tornadoes, thunderstorms, or hurricanes.

"Deserts," too, seems a particularly inappropriate chapter title, for although the dry wastelands are cruel and most unfavorable to man, they hardly illustrate a rampageous nature but, rather, nature in one of its more stable attitudes.

The subject matter of the book should be of interest, but to the serious amateur in meteorology and geology, most of the material is "old hat"; and the scientific purist will be disturbed by the authors' sloppy use of the word "power," when it is "energy" that is being discussed.

Perhaps the plodding nature of the book lies in the self-conscious, almost forced pattern of the chapters. Each starts with a human interest story based on an actual experience, followed by a brief section of scientific explanation. And, as a finale, a bit of the mythology and history of the phenomenon is thrown in. One is left to wonder whether the two authors have any particular interest in any part of this repeated trilogy or whether it represents the publisher's idea for reaching a wide public.

Great Plaza is bounded on the east and west by temples, and lined with stelae. Steps at the left lead to North Terrace.



From air, roof-combs of Tikal can be seen above enveloping rain forest. Temple I, *right*, towers to a height of 160 feet.

Maya Mystery in Tikal

Site reveals long succession of cultures

By William R. Coe

THE SPANISH ACCOUNTS of the complex cultures of Mexico and Guatemala, encountered by the conquistadors in the early years of the sixteenth century, document the end of an intricate cultural development that perhaps spanned 15,000 to 30,000 years. The still-fabulous Aztec capital of Tenochtitlán, the site of modern Mexico City, and all that its urban pattern implied, had its beginnings with the early mammoth hunters of the Valley of Mexico. The climate eventually changed and the large game disappeared. Increasing reliance on the gathering of edible plants laid the groundwork for the eventual and still all-important domestication of corn, beans, and squash. This led, around 2000 B.C., to the emergence of village living, beginnings of pottery-making, and an increasing dependence on agriculture. By 500 B.C. these elements had developed into a significantly more complex situation in which towns dominated by religious precincts and a controlling priesthood were in existence in many localities of what we know as Meso-America.

The stage of village living has been termed "Formative." The achievement of towns, temples, craft specialization, and the beginnings of monumental sculpture and distinct art styles is known as "Proto-Classic." It is on the subsequent "Classic Stage," which lasted for about a thousand years and ended near A.D. 900, that so much archeological interest has been focused during the last fifty years. In this period, the aesthetic and religious trends that were evident in the Proto-Classic stage matured, yielding the many large, small, and diversely detailed "ceremonial centers" of Meso-America. The centers, long-sustained

Two temples on North Acropolis—Structure 34, left, and 33, at right—date to about A.D. 540 and 700 respectively.

by farmers, traders, and religious leaders, were eventually dissolved or were destroyed one by one.

What followed is encompassed by the convenient term, "Post-Classic." This stage in Meso-America saw the ascendancy of the warrior. New peoples came to the fore. The residue of Classic culture was absorbed and recombined. To an important degree, secular controls supplanted those of the priesthood. Dense concentrations of peoples were coupled with the development of true cities. This is the era for which there is so much historical data—data pertaining to the names, lifetimes, travels, intrigues, and conquests of faintly mythical rulers, of the towns they built, of the tribute their conquests allowed, and of the gods they worshiped.

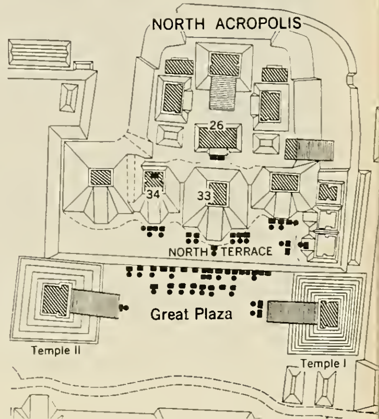
Within Meso-America there occurs a plethora of ceremonial and habitation sites, of languages, art styles, and traditions. Such features coalesce distinctively in a number of regions and times. One recognizes the Teotihuacán, Toltec, and Nahua-Aztec cultures in the area of modern Mexico City; the early La Venta culture of the isthmian area of Mexico; the Zapotec in southern Mexico; and, among others, the lowland Maya culture of the Yucatan Peninsula. It is the Maya, or, rather, their jungle-bound temples and palaces, that have for so long captured man's fancy. The image of the rain forest enclosing the ruins of a high, literate civilization makes a wide appeal to the romanticism that persists among us all.

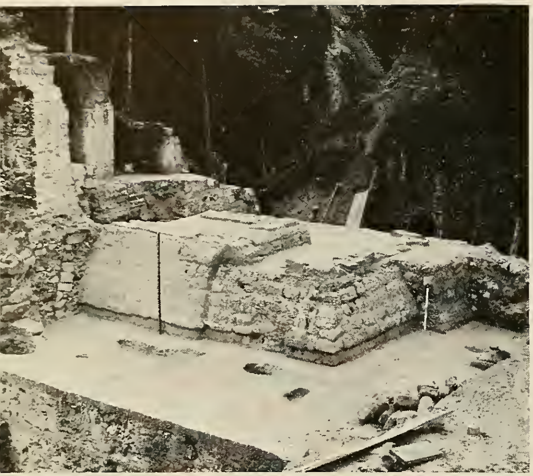
However, it is among such ruins that answers to vital questions of cultural evolution may be found. A cen-

North Acropolis excavation begins by digging of trench at Structure 26, disclosing the superimposed plaster floors.

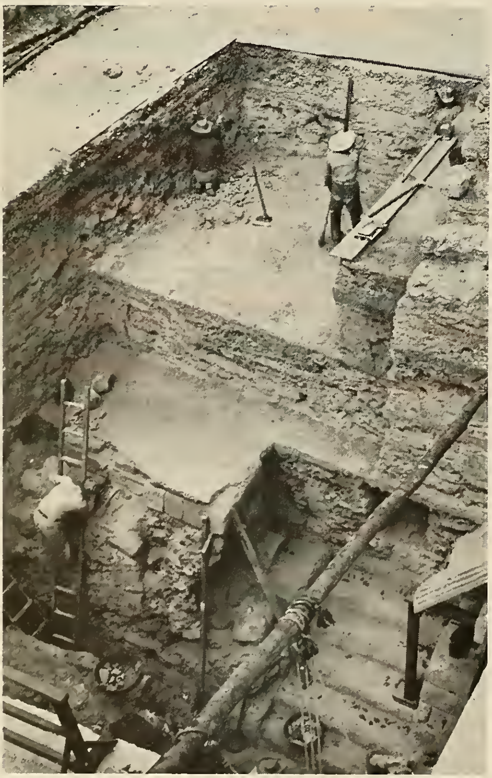
tury of excavation, exploration, and study have done much to document the growth of Maya "cities," and the stages of Maya history. A portion of the hieroglyphic texts given in a few surviving Maya books and on the many stone monuments have been read successfully. Despite all this work there remains a very real ignorance of causes. We still do not know what sustained the priesthood, the temples, and the palaces, nor do we understand what factor or factors dissolved the traditional Proto-Classic and Classic bonds among farmer, craft specialist, and theocrat. Hardly anything can be said reliably about the structure of Classic society. Little is known of the relationships between the many lowland centers, much less of those between the lowland Maya and their linguistic cousins in the Guatemalan highlands, and still less of relationships with other cultural groups within Meso-America. The painstaking slow-

Heaviest excavations have been made in this section of the site. Temples I and II are more than 260 feet apart.



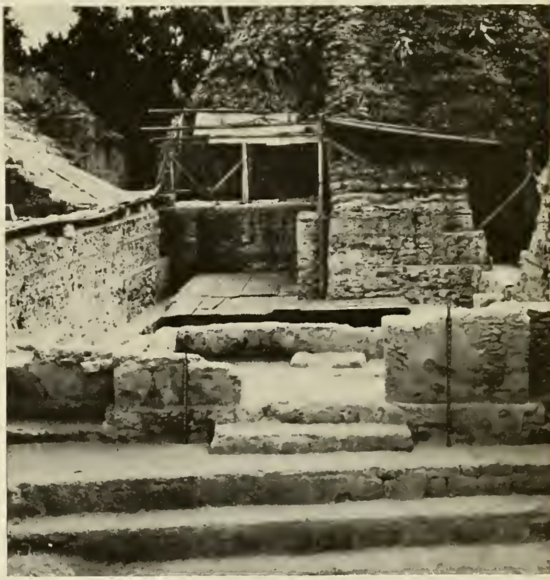


STRUCTURE 26 was found to lie directly over substructure of earlier building, the room walls of which had been razed.



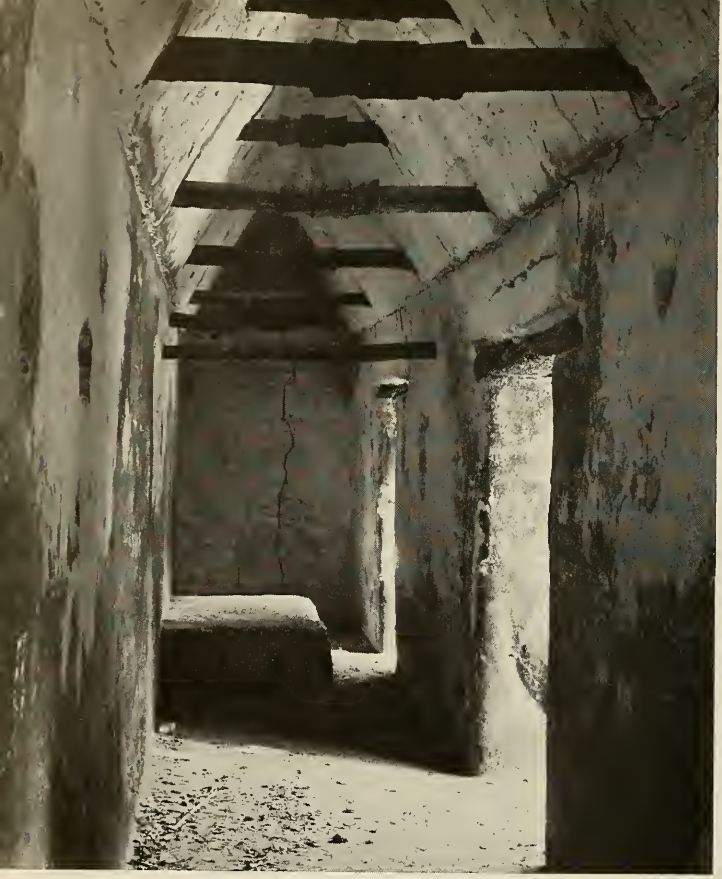
DEEPLY BURIED BUILDING, overlaid by many plaster floors, shows how old structures were used as basis for newer ones.

REMOVING PORTION of old building, top, revealed it, too, had been built over an earlier structure, as seen at right.



As EXCAVATION CONTINUED, five-room house that had once been painted red emerged. A low masonry altar is at rear.

DIGGINGS at south end of the mammoth trench through the North Acropolis are surveyed and carefully plotted on paper.



Spindle-shaped vault beams and plastered vault, walls, floor, and bench are typically Maya, as are wooden lintels.

ness by which factual knowledge is gathered and interpreted through archeology is not often realized.

Archeology as conceived and practiced in the Americas is within the field of anthropology. Although it is doubtful that there has ever been a survey of opinion on the matter, most Americanists probably justify their profession on the grounds that the New World is a sort of "laboratory isolate." As such, it forms a human arena with such theoretically limiting natural boundaries as oceans. The one marked exception (or "experimental variable") is the Bering Strait area, across which men entered the New World from Asia in late Pleistocene times.

The developmental stages and processes by which many of the Old World cultures evolved are reasonably well outlined. So one question that arises in New World studies is the degree to which American Indian culture, in its basic isolation, developed in ways parallel to the Old World pattern. Were the respective rates comparable, and if not, why not? What factors might explain similarities in development on such a scale? The Americas provide a unique testing ground for Old World conclusions regarding the rise and fall of "civilizations" (a term that gains in definition from study of American Indian achievements). In short, the New World offers a special opportunity for a cultural perspective that can hardly be matched elsewhere.

In 1956, work was begun at probably the greatest and most splendid of the Meso-American centers—the Classic Maya ruins of Tikal, in the heavily forested, barely populated lowlands of the Department of Petén in northern Guatemala. Although this site has been known in print since 1853, its extent, both in time and space, have only come to be realized since 1956, when The University Museum of the University of Pennsylvania began a ten-year program of excavation and study there. Under the field direction of Edwin M. Shook, for many years an archeologist of the Carnegie Institution of Washington, the Tikal Project camp was built, and an ambitious program of excavation was started. From its beginning the work had the co-operation of the Guatemalan government — a support substantially expressed in such items as air transportation of supplies and personnel. Until very recently, all project contact beyond remote tropical Tikal was by air, and even now the continuance of scheduled flights from Guatemala City is vital to the project's well-being.

Mapping and excavation have shown that by Late Classic times (A.D. 600-900) the central 6.7 square miles of Tikal contained at least 2,750 structures. The periphery and limits of this massive site remain unknown. Work so far has revealed inscriptions ranging from as early as A.D. 292 to A.D. 869—a span of 577 years. But such absolute dates are only a portion of the record. Below the monumental remains of the Classic Stage at Tikal are equally impressive constructions dating to 100 B.C. The beginning stage of Tikal as a ceremonial center, and the still earlier evidence of local occupation must still be discovered.

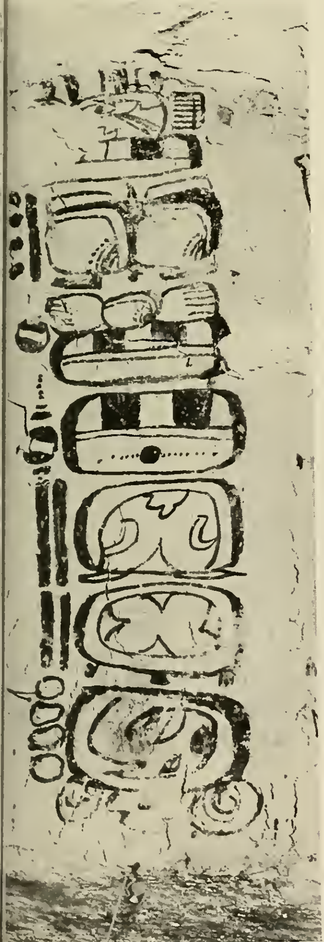
Beyond the archeologist's frank enjoyment in digging, what problems motivate the lengthy and expensive program of work at Tikal? And why choose that particular site, whose very size allows only stringent sampling in its excavation? After the excavations that have been made at such famed sites as Copán, Piedras Negras, Palenque, and Uaxactun, is it possible to expect that finds at Tikal will add appreciably to what has already been learned of the lowland Maya?

The answers to these questions are not simple. First, it is necessary for scholars to know the extent to which the size of a single center such as Tikal contributed to the whole of lowland Maya cultural development. Such a large site might prove to have been an inventive one from which important innovations and traditions of Maya culture diffused. It might also have been exceptionally sensitive to developments at other Maya centers, as well as among other contemporary Meso-American peoples. On the other

nd, the physical magnitude of Tikal uld also imply a capacity to resist ange for the sake of local orthoxy. It was inevitable that the site ould be excavated, if only to examie the relationship between size, ange, and conservatism. Moreover, cheological finds, which elsewhere ght require a year and a fortune to cavate, are sometimes almost fully eserved at Tikal, and can often be und by using nothing much more an an ordinary broom.

There is a second, equally pressing problem—the isolation of factors leading to the initial occupation of Tikal. How and when did the ceremonial pattern, so manifest in Classic times, come to be developed, or, for that matter, perhaps introduced in its essentials? When faced with specific excavation data, how are such distinctions as "Formative," "Proto-Classic," and "Classic" to be given meaning? Why did the long-successful but still-obscure relationship of peasant and priest cease? Eventual failure to carve and erect new stone monuments, or to continue to build and to maintain those already built, may imply the loss of priestly control. The question still remains as to what subsequently happened in Post-Classic times to the farming population, on which Classic achievements must undoubtedly have been based economically.

Dr. Coe, Assistant Curator of the American Section at The University Museum, is also the Assistant Field Director with the Tikal expedition.



Column of glyphs in Burial 48 gives the Maya date equivalent to A.D. 457.

The inferences and conclusions stemming from slow archeological techniques rest on a jungle setting and on the few imperishables such an environment allows. Among the plebian houses and religious precincts, what survives the rot and destructive roots may, when put in chronological order, yield the vital evidences of patterns of living, of traditions, and change. Facts, analysis, ideas, orthodoxies, shibboleths, and confidence in the legibility of what is human—these are the elements that have closely bound Tikal and the excavator like a mute patient and an insistent doctor.

The field season at Tikal runs from January into May, although on occasions it has been possible to operate successfully during the usually wet summer months. Each season sees the further deepening and extension of trenches, the discovery of earlier and earlier buildings, together with carved monuments, further rich tombs, and simpler burials, as well as curious ceremonial offerings stocked with exotic items of flint, obsidian, shell, and jadeite. Analysis of the remains encountered in the excavations has yielded a number of patterns that provide the digger with important means of prediction. Yet, despite a growing sense of control, there are always surprises.

In February of 1961, what has been undramatically termed Burial 48 was discovered. This was a tomb burial. Tomb locations are fairly predictable, although they are not easily reached. Burial 48 turned out to be a small chamber cut into limestone bedrock. Another tomb, with a typical Maya vault, had been built over the area at

Jade and shell mosaic mask, found at Tikal in 1959, is only 1½ inches high.

INCISED BOWL is typical of the pottery used by priests in Early Classic times.

VESSEL with bird top shows influence of great Teotihuacán site in Mexico.

a later date. Masonry, which blocked the entrance of the earlier tomb, was gingerly removed. A light was thrust through the opening, and what had never been anticipated was first seen—a room nine feet long (a "cave" would be more apt), whose walls were covered with plaster and painted with immense black hieroglyphs. Directly opposite the sealed entrance was a vertically painted "Initial Series" text, recording the Maya date 9.1.1.10.10 4 Oc, which later in camp was translated as A.D. 457. Little was visible beyond the painted chamber walls, as the bedrock ceiling had badly scaled, thus effectively covering the interment on the floor of the tomb.

NEARLY a month was required to excavate and record this extraordinary discovery. The work was dangerous, cramped, and generally stifling. But the astonishing finds were, to the dedicated, worth any amount of discomfort. Some of the outstanding objects are pictured on these pages. What cannot appear was the principal skeleton, which was flanked by two adolescents. The person to whom this sumptuous tomb belonged must have been important—probably a priest-ruler. Oddly, no trace of his head was found, nor could one be sure that he had been buried with intact hands. Large jadeite earplugs and necklaces accompanied him. To one side, magnificent vessels of pottery and one of alabaster had been set. On the other side were many plain vessels containing the barely recognizable remains of foodstuffs, including birds. The text painted on the plastered walls of the tomb may record the man's birth or death date or, conceivably, that of his accession to power as a priest.

Of course, the day-to-day work at Tikal is rarely favored with a Burial 48 or with a report of a new carved stela in the previously unmapped jungle. It consists, instead, of picking and troweling one's way deeper and further back in time through floors, walls, and construction fills. The bulk of the work pertains to architecture, from the very elaborate temple to the simple but substantial domestic structure. The objective is always to develop a fully controlled and fully recorded physical sequence, or stratigraphy.

The procedures in excavation and its aims can be best-illustrated by the work done and still in progress in and about the central Great Plaza area. The

Bird Motif of lid top, *lower left*, is repeated in incising on side of vessel, *above*. Piece is six inches in diameter.

Great Plaza itself was found to consist of five plazas, each new one built directly over its predecessor, and each represented by a plaster floor about twice the size of a modern football field. The top two floors are linked to long rows of stone altars and stelae. The dates on certain of these monuments provide a basis for dating the construction and use of these plazas. Broken pottery sandwiched between floors give additional indications of dates. The mammoth Temples I and II have been tied together by their respective associations with these floors.

Tunneling within the 160-foot-high Temple I has disclosed the existence of a completely buried earlier temple. The sequence of plaza floors has been followed to the North Terrace. which fronts the spectacular North Acropolis —an unparalleled assemblage of Early Classic temples. Over the course of three seasons, the North Terrace was probed and found to consist of eight superimposed terraces. each some 300 feet long. Charcoal from the earliest ones was analyzed by the radiocarbon method. and the results indicate that these immense terraces were built in the first century B.C.

The sequence of terrace floors, once related to the Great Plaza sequence,

Band of hieroglyphs appears below green-painted rim of a partly disintegrated alabaster bowl found in Burial 48.

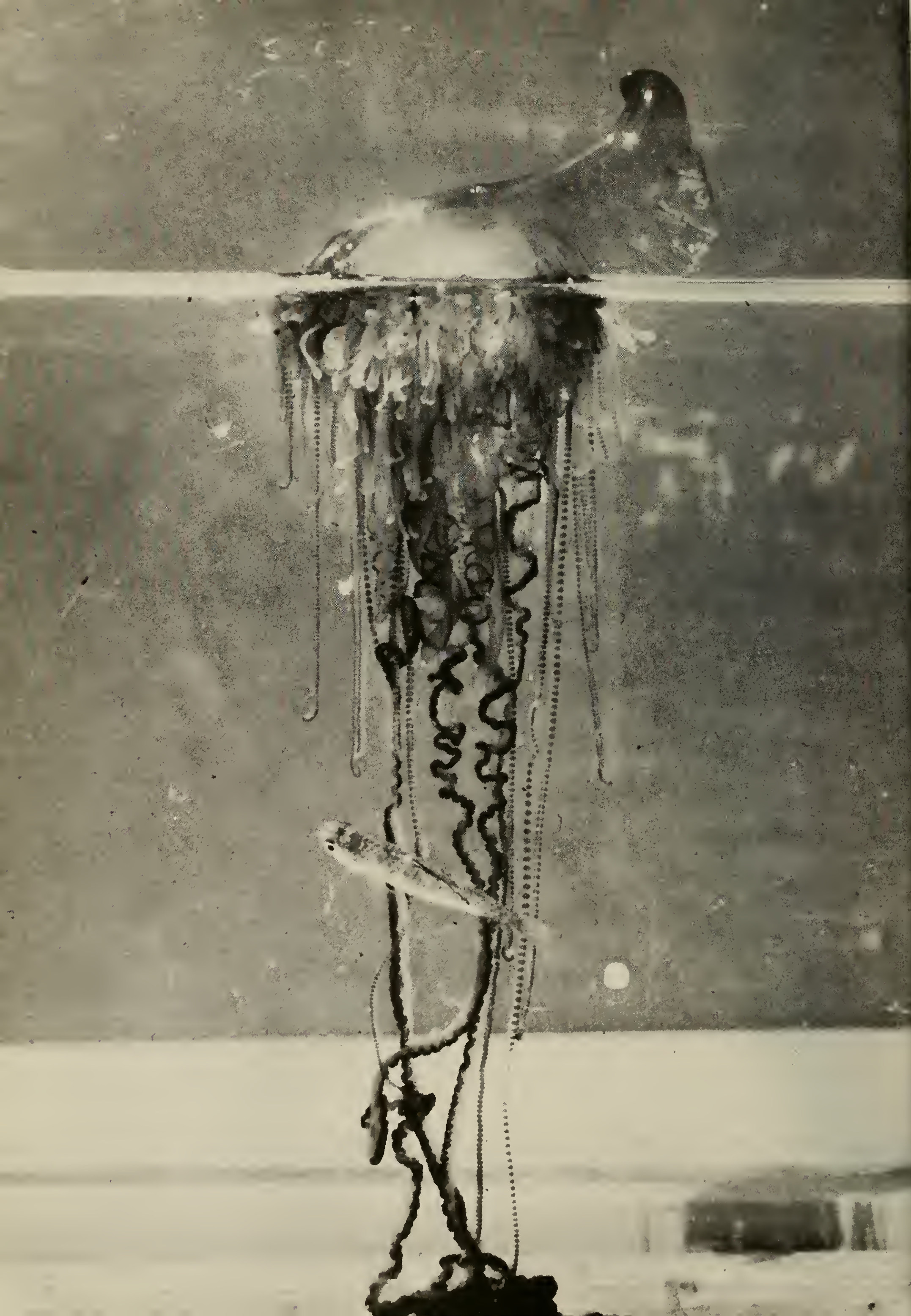
served to place in time the construction of a number of large temple buildings on the south side of the North Acropolis. The many monuments supported by the terrace were similarly linked to the terrace floor sequence. Deep trenches and tunnels into the temples have again provided important evidence of final buildings that conceal earlier versions. It is in the course of such work that burials, including the one just described, are discovered.

In 1960, the major excavation effort was shifted onto the North Acropolis proper. The Acropolis is basically a high, rectangular platform supporting eight formally arranged, closely set temples. This is one of the few places at Tikal at which Early Classic buildings were not built over in Late Classic times. Preliminary test digging showed, as expected, that the Acropolis platform was the result of a long period of construction. Beneath the eighth floor were found the well-preserved remains of a large building. Clearly, the North Acropolis had grown by stages, with each major stage supporting later buildings.

This deeply buried structure, with great stuccoed masks flanking its stairway, was obviously early. But to specify *how* early required types of information not then at hand. For one thing, this portion of the North Acropolis had not yet been linked to the stratigraphy and temporal controls of the North Terrace and Great Plaza. The latest identifiable pottery from the deep fill overlying the buried building was of a type called Matzanel—the ceramic hallmark of the local Proto-Classic stage. This fact indicated that the building had been abandoned and buried no earlier than at a time when such pottery was in vogue. It could not be assumed that the building was buried during Matzanel times (within the first two centuries A.D.), because of the uncertainty as to where the overlying fill containing this pottery actually originated. The possibility existed that the fill stemmed from a by-then-ancient dump. On the other hand, a trench into the building might produce a tomb containing pottery. If the tomb could be shown to have been installed just prior to or during the construction of the building, and if the pottery vessels were not heirlooms, the types of pottery—with their approximate ages known from similar work found elsewhere—could be used to date construction. However, at a depth of 25 feet, within the confines of an exploratory pit, real problems of logistics were raised. Proper excavation of the building had to be delayed until planned, adjacent excavations had been carried to an equivalent depth.

Clearly, the objective was to expose the complex development of the North Acropolis platform and buildings, stage by stage. A description of this project will be presented in detail in the October issue of the magazine.

Stucco painted red, green, and white adorns this cylindrical tripod vessel.



Floaters of the Sea

Long tentacles of Portuguese man-of-war paralyze a fish that has touched nematocysts, *left*, which expel poisonous threads like harpoons. Immobilized prey, *above*, is lifted to clusters of feeding polyps by contraction of tentacles.

Siphonophore structures help colonies maintain specific depth

By Werner Jacobs

Paradoxical as it may sound, many of the various animals and lower plants that live permanently or temporarily in the open ocean are in danger of sinking. The fact is that the specific gravity of protoplasm is about 1.05—and many other constituents of living organisms are far more dense. On the other hand, the specific gravity of normal sea water (a 33 per cent salt concentration at 60°F.) is only about 1.025. Thus, marine organisms would sink were it not for various devices that have evolved to keep them afloat. Some very small organisms use water turbulence to keep from sinking; other forms swim continuously. Another and particularly interesting response to the problem is shown by the group known as floaters. The specific gravity of the animals' bodies is adjusted to somewhat less than that of sea water by the internal production of material lighter than the surrounding water.

Among the floaters are the siphonophores, distant relatives of the large, free-swimming marine jellyfish and of the sea anemones and permanently attached corals. They are more closely related to the small, fresh-water polyp, *Hydra* (Natural History, November, 1959), and its marine cousins, the other Hydrozoa. All of these animals possess microscopic weapons known as nematocysts, with the aid of which they overcome their prey. When certain nematocysts are touched, they expel a harpoon-like thread with enough force to penetrate fairly tough surfaces (for instance, the carapace of a small shrimp or copepod). Frequently, the thread contains a poison that paralyzes the victim. That of some species is very irritating to human skin, and the sensation is rather like that of grasping stinging nettles.

Many members of the Hydrozoa occur in two forms: a sedentary polyp that may be associated with other polyps in colonies, or a free-swimming jellyfish, or medusa. The two forms are related to each other as follows: the polyps produce medusae by budding, a process of asexual reproduction; the medusae, in turn, produce sperm or eggs in a sexual generation, and the eggs, when fertilized, develop

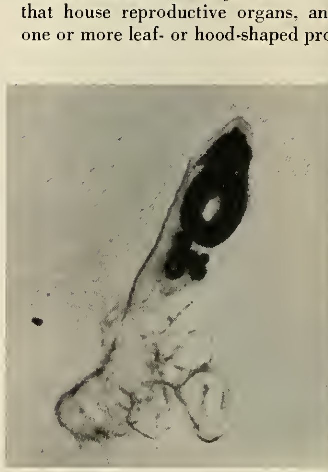
Two swimming bells of *Galeolaria*, at left, and clustered swimming bells of *Hippopodius*, at center, let creatures change depth. *Stephanomia*, at right, when disturbed, can sink by releasir a bubble of gas from its gas sac, to]

into free-swimming larvae that attach to the substrate and develop into asexual polyps. This cycle of alternating generations may be obscured and reduced in certain species. In these, medusa buds are produced on the polyp but do not develop into free-swimming individuals. Instead, they remain attached to the polyp and, occasionally, the typical medusa shape is only remotely indicated. On the other hand, there are some forms that lack the polyp stage, and the fertilized egg of a medusa develops into another medusa, or a medusa buds off another.

Most biologists regard siphonophores as polymorphic colonies that consist of a set of individuals having basically a polyp or a medusa structure. Frequently, however, the individuals are so specialized in function that, rather than seeming to be parts of a colony, they resemble different organs of a single individual. All siphonophores—each a colony of individuals—float freely in subsurface oceanic waters or drift on the surface. Two main groups, the Pneumatophora and the Calycophora, may be distinguished by the morphology of the upper portion of the colony.

The body of one of the Pneumatophora has many regions and may be as transparent as glass. The thread-like axis contracts and relaxes at intervals, and at the uppermost end a minute, silvery bulb of pinhead size can be distinguished. This is the gas sac, or pneumatophore, an oval structure filled with a small quantity of gas. Behind the sac is a double line of swimming bells, each of which is simila to a medusa and somewhat resemble a bell without a clapper. Rhythmi contractions of the bell wall expe water through the structure's opening which points obliquely downward. Th series of bells is about half an inc long. When all bells are active, the en tire colony moves slowly forward wit the pneumatophore in front.

Behind the region of swimmin bells, the stem drags like a rope. It ma be up to one foot long, and it carrie organs of diverse form and function combined in groups like beads on a thread. Usually, each stem group has one feeding organ, with a trumpet shaped, expansive mouth. Further there are the medusa-shaped structures that house reproductive organs, and one or more leaf- or hood-shaped pro-



Full gas sac of *Stephanomia* is shown excised, *left*. In the center, the gas is extruded from the sac with laboratory apparatus. Soon, new gas is produced in the form of minute bubbles, which are visible in tissue of gas gland, *right*.

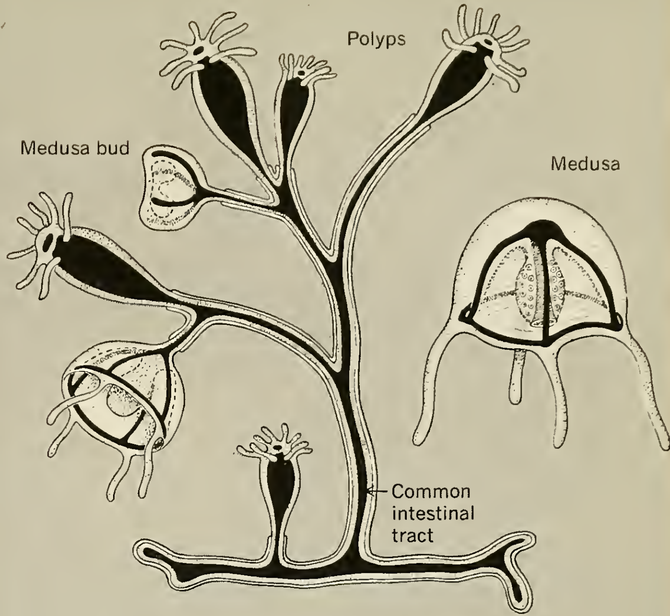
ective structures covering the whole group. Finally, and of great importance, each stem has a long, contractile tentacle. On small, lateral filaments, the tentacle carries many nodules, often bright red or yellow, with numerous nematocysts concentrated in each one. When the siphonophore's prey — usually a copepod — has been paralyzed, it is carried to the feeding organ by contraction of the tentacle.

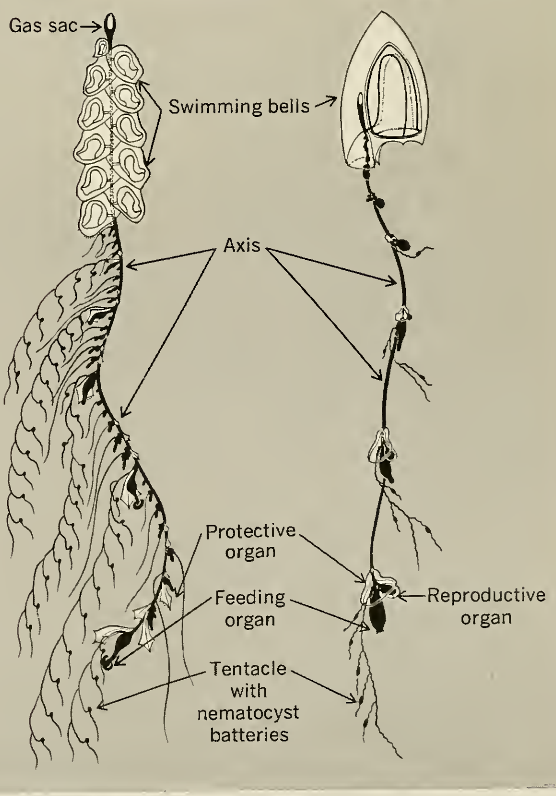
Members of the Calycophora group lack a gas sac. Instead, they carry one or more large, occasionally very elongate, swimming bells. *Diphyes* and *Galeolaria* have two; *Hippopodius* has several at the front of the axis.

When the surface of the water is choppy, one does not find the smaller and more delicate species of siphonophores in the upper layers of the sea. At such times they descend to calmer levels. The Calycophora use their rather powerful swimming bells to effect these depth changes. Several of the Pneumatophora, *Stephanomia*, for example, do it differently: through a fine pore at the top of the gas sac, which can be closed by minute muscles, gas may be released. If one disturbs a *Stephanomia*, gas escapes and, as a consequence, the body sinks.

Although the gas sac of *Stephanomia* is very small indeed, when completely filled it supports the whole colony. If the sac is cut off, even the siphonophore's numerous swimming bells cannot prevent the whole colony from sinking. On the other hand, a colony that has been induced to release gas and dive will soon come up again, provided the water is quiet, because the gas sac can be quickly refilled. The process of gas secretion can be readily observed under the microscope. Application of slight pressure forces the sac to extrude gas. A few seconds later, tiny new gas bubbles appear at the bottom of the sac, within a special tissue called the gas gland. The bubbles increase quickly in size, fuse, and fill the sac of the *Stephanomia*.

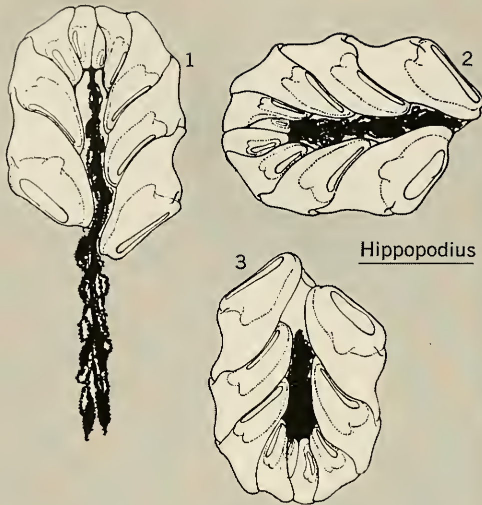
Presumably, gas release and gas formation are delicately regulated in response to local circumstances. However, the mechanism of regulation is poorly understood. Some of my analyses indicate that carbon dioxide and oxygen apparently do not play any significant role in the formation of new gas. Measurements in *Stephanomia* have shown that the gas sac contains on the average about 2 per cent



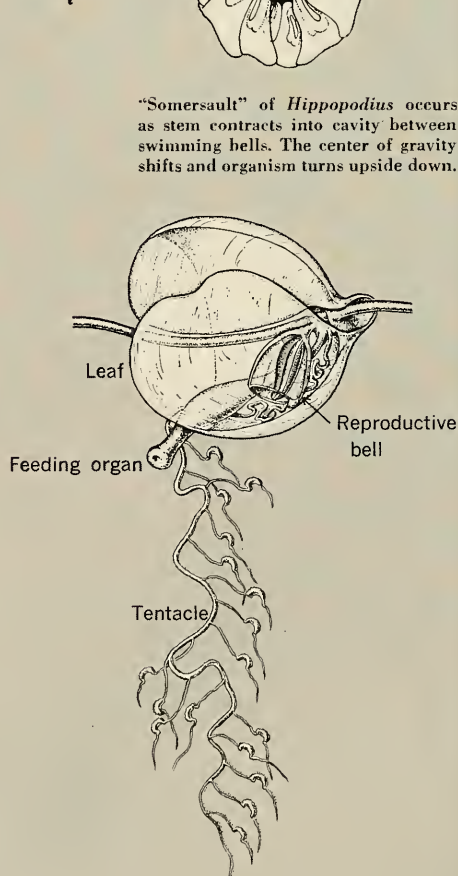


Polyp colony, top, produces medusae and polyps by budding. Two main types of siphonophore are compared below: a Pneumatophora, left, and Calycophora.

Buoyant protective leaves cover stem of *Agalma* and prevent the colony from sinking. The gas sac, at top, is able to support only anterior part of stem.



"Somersault" of *Hippopodius* occurs as stem contracts into cavity between swimming bells. The center of gravity shifts and organism turns upside down.



Each of many organ groups on axis of *Galeolaria* consists of feeding organ, a reproductive bell, a tentacle, and a large, buoyant leaf covering the group.

carbon dioxide and 11 per cent oxyg when the colony is at rest, and abo 2.5 per cent carbon dioxide and 5 p cent oxygen a few minutes after con pletion of the filling process.

Comparison with another wel known hydrostatic gas organ, the swi bladder of fishes, is interesting. Her also, gas may be removed and the replaced by the activity of gas gland However, in the latter case, oxyge is the principal gas that is secrete Also, carbon dioxide often appears i considerable quantities, and in man cases, a secretion of nitrogen and ine gases, especially argon, has been dem onstrated. The microscopic siphono phore larvae swim by beating tiny hairlike cilia, with which they are cov ered. Soon after hatching, the larva elongate and two poles may be clearl distinguished: at one end the futur mouth of the first feeding polyp i indicated by dark pigmentation; at th opposite end the structure of the futur gas sac can be recognized. Then, a one point in the development of th larva, the tiny sac is very quickly in flated with gas.

Probably the best-known of all the siphonophores is *Physalia*, the Portuguese man-of-war, a giant member of the Pneumatophora. The man-of-war's gas sac is very large—up to twelve inches long—while its extremely short stem is virtually a disc. Feeding organs, reproductive organs, and long tentacles hang below the gas sac. Because of its great size, the gas sac cannot submerge, so the colony floats permanently on the surface of the sea.

The man-of-war shows an interesting adaptation to life on the surface. The gas sac is crested, and when the wind blows against the crest, it is erected by muscles and serves as a sail by which the very large siphonophore is driven along.

Among many Pneumatophora the gas sac is not exclusively responsible for the colony's floating; it may even be of little significance. *Forskalia* and *Agalma*, for instance, do not sink at all if the gas sac is cut off; the front of the stem merely bends down slightly. These species of the Pneumatophora are distinguished by the presence of numerous, gelatinous protective leaves. The importance of the leaves to floating becomes apparent at once if the colony is shaken vigorously; the loosely attached leaves fall off and rise to the surface, while the rest of

the colony sinks. Obviously then, the colony is primarily supported by the gelatinous leaves, which are somewhat lighter than sea water.

This floating method is especially well developed in many of the Calycophora. *Hippopodius*, for example, is supported exclusively by its gelatinous swimming bells, which rise to the surface if they are cut off. It is amusing to see a *Hippopodius* somersault when it is disturbed. The tilting is caused by a shift of the colony's center of gravity. The stem and its appendages are relatively heavy, and normally they hang vertically. When disturbed, the stem contracts strongly and the appendages are lifted to a position between the swimming bells. Thus, the center of gravity is shifted to the top of the colony and the whole body turns over. Since in this new orientation the swimming bells expel water upward, the colony is actually able to propel itself downward.

Among the Calycophora, both *Diphyes* and *Galeolaria* have two swimming bells at the front, one behind the other. The bells are of unequal size: the larger one always has a much thicker gelatinous wall. In *Diphyes* the larger bell is the foremost, whereas in *Galeolaria* the larger is second. The normal resting position of the colony's front part in these two species is therefore quite different, because, whatever the colony's position, the larger bell always points upward. It should be noted that in *Galeolaria* only the very first part of the stem hangs down. The longer end floats more or less horizontally because it is buoyed up by its large protective leaves, each of which covers one of the rows of stem groups situated along the axis. Each group consists of a feeding organ, a tentacle with nematocyst batteries, and a region containing the reproductive organs.

DR. JACOBS is a professor with the Zoological Institute of Munich. He observed living siphonophores at the Zoological Station in Naples, Italy.

SOME of the Calycophora are able to regulate the specific gravity of the colony to a degree. A colony of *Hippopodius* or *Diphyes* may be lighter than sea water at one time and heavier at another. However, such weight changes occur slowly, over the course of approximately an hour.

It is still not known why the gelatinous substance of these leaves and swimming bells is lighter than sea water. Possibly the material contains salts of a different composition, or at a lower concentration, than the surrounding sea. Such cases are well known in other marine organisms. *Noctiluca*, for example, one of the producers of marine luminescence, is a tiny, sphere-shaped flagellate about 1 mm. in diameter. The salt concentration within its cell is the same as that of sea water. However, the cell contains primarily ammonium chloride, whereas sea water contains principally the heavier sodium chloride. Hence, *Noctiluca* is slightly lighter than its environment. On the other hand, it seems that the marine diatom *Ditylium brightwelli* is in a floating equilibrium with sea water only when the cell fluid is extremely low in salts.

All the smaller, non-swimming ocean plants and animals are faced with the problem of maintaining a specific depth. Diatoms, protozoans, minute crustaceans (larvae and adults alike), pelagic worms, snails, and ascidians, each has a method of meeting this problem. The Siphonophora show one more of the many adaptations that have evolved in their use of gas flotation and differences in specific gravity.

PORTUGUESE MEN-OF-WAR float in water off Spanish Harbor Key, Florida, near Gulf Stream. Crest on top of each gas sac is erected by muscles. The crest serves as a sail for the man-of-war, catching wind and thus moving the colony.

nee-deep in a pond on
ıpe Cod, this small
sident looks closely
r evidence of water
'e among the slender
pewort flower stalks.

Soft feathers and firm body of a mounted bird are stroked by natural history student at an exhibit in summer tent erected on museum land.

Lessons in Stones, Plants and Ponds

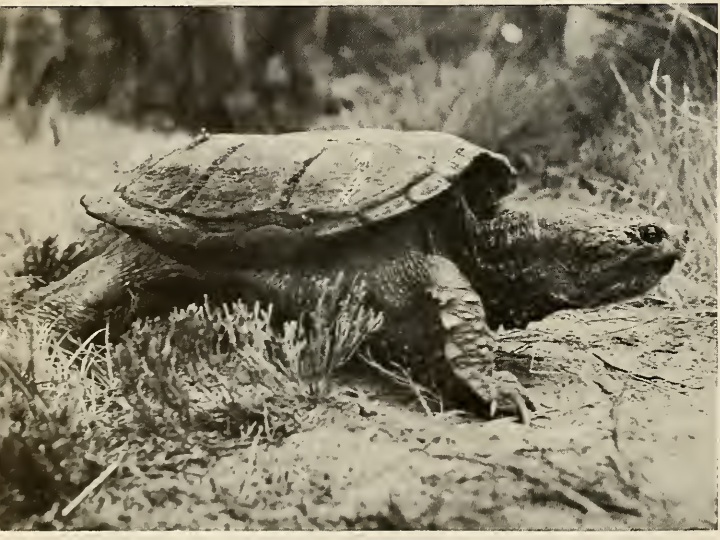
Cape Cod Museum teaches natural history on its own land

THERE ARE MANY WAYS in which a child can learn, but when the subject is the world around him, the most valuable and lasting way is for him to experience that world firsthand—to touch, to smell, to look, to hear—preferably under the guidance of a knowing adult. This is the thesis of the Cape Cod Museum of Natural History, which was founded eight years ago as a junior museum.

The setting is ideal for the project. Forty-eight acres of land include marshes, valleys, hills, streams, woodland, and fresh-water ponds—a wonderland of wildlife. The museum's other great asset is the availability of year-round residents with some training in the field of natural history. Two of these are Dr. Loren C. Petry, a retired botany professor from Cornell University, and Dr. Ransom Somers, formerly with the geology department at the same institution. They, together with others interested in various aspects of nature, are undertaking the job of instructing the young people. At the beginning, headquarters were in Brewster Town Hall, where some classes still are held. Next came a roadside tent for housing summer exhibits. These pages show some of the things there are for children to do outdoors, and the great excitement in the doing of them.

By JOHN HAY   Photographs by ARLINE STRONG

Whistling with a blade of grass is not as easy as it appears. An admiring friend watches carefully while a young musician plays a solo in a sunny, wooded setting.



Female snapping turtle, which lays its eggs on land, spends most of its time in the water. Animal has a horny beak, strong jaws, and such a short temper even grownups approach with caution.

"This kind of sumac isn't poisonous," says Dr. Petry. Absorbed children are learning to recognize common plants and their properties, while receiving a basic course in observation methods.

Members of a nature class tread softly along edge of pond looking out for water life. Large net is tool of exploration to be used for dipping up pond's secrets.

"What do you suppose this is?" Many wonderful things were trapped with a random sweep of the net along the water's edge, and nature's grab bag is eagerly studied.

STUDENTS of natural history can study hundreds of forms of life—both plant and animal—that inhabit the area's streams and glacial ponds. Nature classes are regularly conducted to such locations, some of which are on museum property, some in the regions bordering it. Aquariums and miniature ponds constructed by staffers allow the children to observe more closely the life they only glimpse now and then in natural pools. For aspiring geologists, there are classes, informal and often conducted out of doors, for the study of rocks, Cape Cod geology, and geologic mapping. Under the guidance of a local potter and artist, youngsters with artistic interests learn to apply the forms in nature to clay. Nature walks and games of identification are part of the annual program, too. As an adjunct to its work, the museum supplies loan exhibits to local schools, and has a growing natural science library.

One function of the museum staff grew out of necessity. For various exhibits, mounted specimens were needed, but taxidermy was too expensive an item for the young museum. So some of the staff members enrolled in classes at the Boston Museum of Science and learned how to do the work themselves. This approach to their subjects has grown from the staff's conviction that a child must be given the opportunity to know his natural heritage. The popularity of the program is an indication of the theory's success.

Moon snail, its powerful foot creeping helplessly on the hand of the child who discovered it in the water, looks little like an animal that preys on shellfish.

Careful study is needed to find out exactly what a rock is made of. Dr. Somers looks at a specimen with hand glass as young "rockhounds" watch.

Cape Cod Bay is background for class in geology, and Dr. Somers explains the origin of loose rocks left by glaciers many thousands of years ago.

Breathing tubes are visible above partly submerged heads of these "water babies," who are interested at the moment in a group of sea anemones.

A rock picked up on the beach or a snail scooped from its watery habitat are objects of wonder to a child. But if his questions about things in nature are consistently ignored, he may grow up with little interest in his surroundings. There are reasons for a rock's ragged edges. To explain them with such a rock in hand at the moment of his inquiry is to introduce the earth's processes to a highly receptive mind. Curiosity so rewarded increases a child's understanding of himself as part of a changing world.

Is it a bullfrog or a green frog? How to identify it is explained with a living specimen held belly up in the carefully restraining fingers of an aspiring naturalist.

To catch a dragonfly, even one as big as this "darning needle," is no easy job. It's even harder to hold it so gently that, after it has been studied, it can fly away.

Water lilies bloom among their green leaves in rippled Cape Cod pond. Their presence means water is fairly shallow, although it may still be too deep for wading.

These clay pots, lovingly molded, smoothed, and then baked in the sun, embody many of the shapes, textures, colors, and light and dark observed throughout nature.

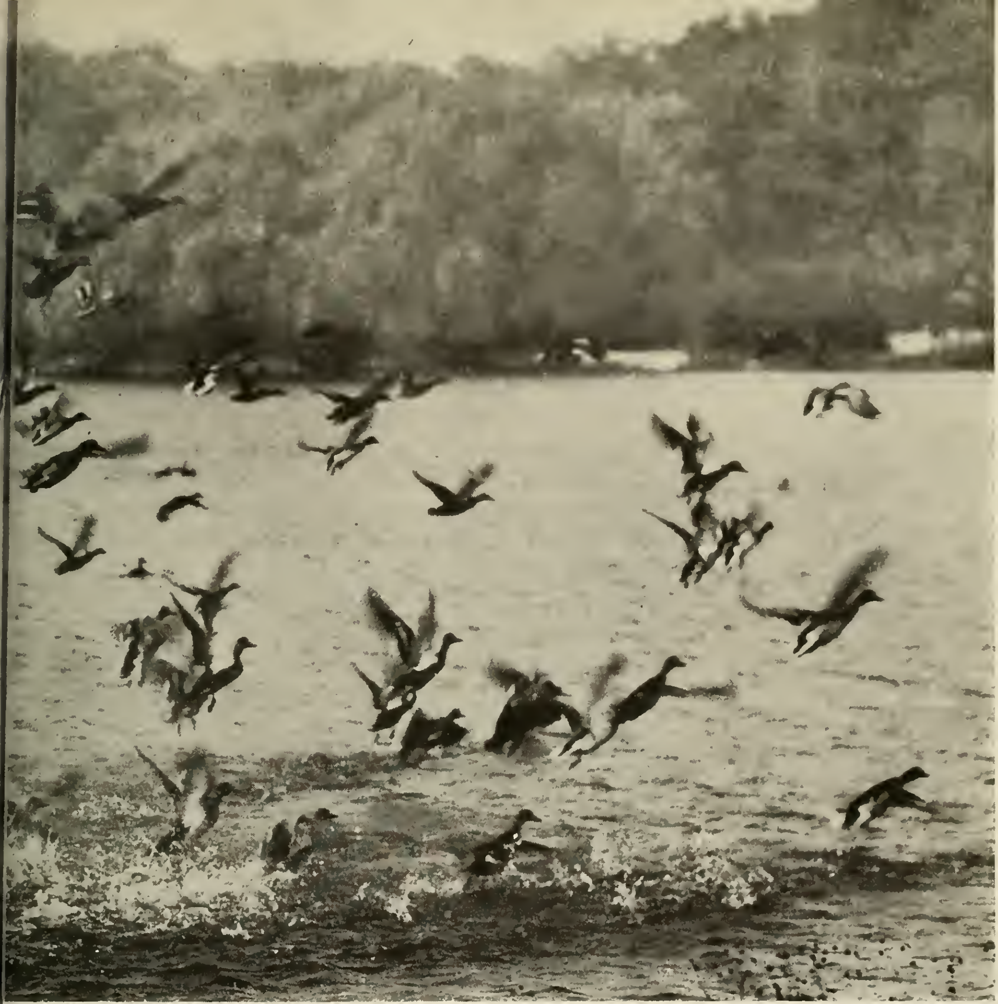
A Speed Trap for Birds

Specially devised radar unit measures flight velocity by Doppler frequency

By Wesley E. Lanyon

Anyone who has watched a peregrine falcon swoop on its prey or the labored flight of a great blue heron over a marsh has very probably entertained some questions as to how fast the birds were flying. Many sportsmen, too, have speculated upon the speed of ducks as they winged over a blind; or of quail exploding into the air before the pointing dogs. Experiences such as these kindled the interest of F. Trubee Davison in the speed of birds in flight. Mr. Davison, a former president of The American Museum of Natural History, turned to the Museum's Department of Ornithology for information, only to discover that no comprehensive scientific investigation had ever been made in this particular area.

This is not to say that there are



no published flight speeds. There are numerous references attesting to how fast this or that species was flying, but measuring techniques have been crude. Most records have been obtained by reading the speedometer of an automobile or the air-speed indicator of an airplane while the observer moved parallel with the bird's line of flight. There are obvious difficulties in matching the speed of a flying bird with that of a vehicle, and such "games" can be hazardous. Aside from the inaccuracies of the meters involved, there are other sources of error. No adjustments can be made for the influence of wind or thermal currents, so that the investigators are actually measuring traveling speed (or ground speed) rather than the bird's true flying ability. A songbird capable of a top speed of 20 miles per hour being carried along by a 15-mile-an-hour tail wind might register a ground speed of up to 35 miles per hour. Similarly, the osprey has been known to reach a traveling speed of 80 miles per hour without flapping its wings, simply by sailing along the top of a strong thermal current.

Another technique is using a stop watch to time a bird's flight over a measured course to discover its average speed. It is impossible to determine the maximum flight speeds of many species by this method, because of peculiarities in individual flight behavior. For instance, the black vulture has an alternating flapping and gliding flight; the bobwhite flushes with a sudden burst of speed, which is followed by a prolonged glide.

An ingenious method for determining maximum flight speeds has recently been used successfully by Crawford H. Greenewalt in his remarkable studies of hummingbirds. A wind tunnel was constructed, and a powerful fan was placed at one end. The fan's output could be varied to produce a head wind of any given velocity, and a feeder was placed at the exit end of the tunnel. A hummingbird, entering the tunnel to feed and confronted with a head wind of a specific velocity, would perform as though it were flying at that speed, although its position with respect to the feeder would remain stationary. By carefully increasing the wind velocity in the tunnel, it was possible to

determine at what critical point the bird was unable to maintain its position in the current of air. The fastest "speed" attained by a ruby-throated hummingbird in these experiments corresponded to a wind velocity of about 27 miles per hour, and it was concluded that under natural conditions the top speed for this species is probably under 30 miles per hour. Since there are records in the literature crediting this bird with speeds of up to 60 miles per hour (as determined by pacing a bird a short distance with an automobile), Mr. Greenewalt's results are revealing, and demonstrate the limitations of crude field techniques.

Such a controlled, experimental approach to measuring the flight speeds of birds has particular promise in studies of the relation of speed to different shapes and activities of birds' wings. It has its limitations, of course, in determining the speeds under a variety of environmental and behavioral situations that exist in the wild.

The problem of developing instrumentation to determine flight speeds under more natural conditions was presented to a number of engineers. Consideration was given to a variety of optical and electronic possibilities, but radar appeared to hold the greatest promise. Orville Dunning, an outstanding radar engineer and an enthusiastic amateur ornithologist, undertook the design and fabrication of this unique equipment. The result was a Doppler radar unit specifically engineered to ascertain flight speeds. It was delivered to the Museum's Kalbfleisch Field Research Station at Huntington, Long Island, where, as Resident Director of that Station, I put the equipment through some preliminary field tests. Additional experience with the equipment was gained with several species of game birds in northwestern Florida.

The principle of the Doppler radar unit is similar to that used in police radars on our highways. Radar echoes from moving targets are shifted in frequency in a manner that is determined by the target speed. By detecting this shift, a direct measure of the target's speed may be obtained. The radar unit consists of five basic elements: (1) a transmitter that provides a source of one half watt of microwave energy at 9,600 megacycles per second; (2) a transmitting antenna to direct and focus this energy on the bird in flight; (3) a receiving antenna to collect the

Radar unit, focused on hand-released, white-throated sparrow, transmits tone of Doppler frequency to earphones and measures speed on frequency counter.

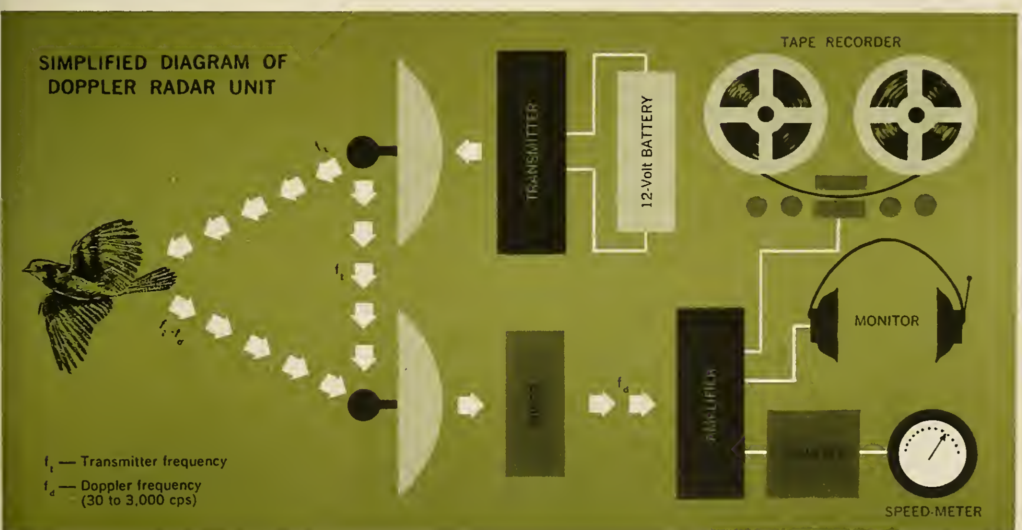
energy reflected from the bird; (4) a mixer to mix the reflected energy with a small sample of the transmitted energy; and (5) a receiver to amplify and measure the mixer's audible output frequency—the Doppler frequency.

The radar unit contains its own storage batteries that, when fully charged, are capable of operating the set for about 30 minutes. Under normal field conditions, however, an external 12-volt automobile battery is used as the power supply. When the radar beam is pointed at a moving bird, a tone is heard in the monitor earphones. The pitch, or frequency, of the tone (the Doppler frequency) is an indication of the bird's speed. Slow-moving targets produce low tones; fast-moving targets produce high tones. Associated with the receiver is a frequency counter that measures the Doppler frequency and presents it on a "speed-meter," where the operator may read the speed directly in miles per hour. At the same time, both the Doppler frequency and a voice commentary are recorded on a battery-operated tape recorder to provide a permanent record of the field work.

The tape may subsequently be analyzed in the laboratory, where the Doppler frequencies are converted into miles per hour. One method of analysis involves a sound spectrograph, which has been rather widely used by biologists in recent years, especially in studies of animal sounds and communication. It provides the investigator with a pictorial record of sound—in this case, of the Doppler frequencies registered on the tape. Each record, or sound spectrogram, illustrates the tone in terms of pitch, or frequency, (in cycles per second) and its duration in time. For our purposes, the frequency can readily be converted into miles per hour by dividing the number of cycles per second by 28.5—a mathematical constant expressing the relationship between frequency and flight speed. Most of the Doppler frequencies obtained from flying birds appear on the sound spectrograms in the 0 to 2 kc. range (0-2,000 cycles per second), representing flight speeds up to approximately 70 miles per hour. It is possible, however, to record and analyze even higher speeds.

The Doppler radar, like most scientific instrumentation, has limitations with which the operator must be thoroughly familiar to prevent the results from being erroneous or misleading. A Doppler frequency will be recorded from a bird flying either toward or away from the radar unit, but there must be little, if any, deviation from the "straightaway" or "straight-toward" position. That is, for recording accuracy, there must be no significant angle of deviation between the direction of the radar beam and the direction of the target's flight. Fortunately, the error between the "indicated speed" and the "true speed" is not significant, provided the angle of deviation is not greater than 20 degrees. If the Doppler frequency suggests a speed of 20 miles per hour for a bird flying at a 20-degree angle to the radar beam, the bird's actual flight speed is 21.3 miles per hour. This error is only slightly greater than that obtained in laboratory conversions. All of the sound spectrograms accompanying this article were made from radar echoes received with less than a 20-degree angle of deviation. If, on the other hand, a bird is flying at an indicated speed of 20 miles per hour *at an angle of 40 degrees*, its true speed is actually 26.2 miles per hour. Fortunately, should the operator be unable to reduce the deviant angle below 20 degrees, the true speed can be determined mathematically from the indicated speed, providing an estimate can be made of the deviant angle.

Another limitation in this instrumentation lies in the transcription and analysis of the Doppler frequency. The accuracy of the conversion from frequency in cycles per second to flight speed in miles per hour depends upon the fidelity with which the Doppler frequency is recorded on magnetic tape and later reproduced for analysis. The frequency of recorded sound is governed directly by the speed at which the tape moves across the reproducing head of the recorder—a speed that can be highly variable according to the specific instrument used and to the condition of the batteries



powering the field recorder. There is, then, a very real problem in guarding against misrepresentation resulting from changes in the speed of tape transfer during playback and analysis. A simple safeguard is for the operator to record the tone of a pitch pipe at the beginning of each field recording. In effect, this places on the tape a known frequency that can be used as a standard of reference. An "A" pitch pipe was used in the field tests reported here, affording a 440-cycle reference point (plus harmonics).

Although portable in one sense, the Doppler radar unit is not mobile enough to permit its indiscriminate and extemporaneous use under field conditions. This limited mobility, coupled with the need to maintain a small angle of deviation between the radar beam and the direction of flight, restricts the use of the unit to situations where flight patterns are fairly predictable. In other words, it would be a waste of time to establish a tracking station in the field at random in the hope that sooner or later a flight pattern could be intercepted.

Preliminary field tests have shown a number of situations in which Doppler radar holds particular promise for obtaining more objective and accurate flight speeds. In one of these, birds were hand-released near the radar unit and their straightaway flight was tracked across an opening toward the shelter of a wooded area. Birds banded at the Kalbfleisch Field Research Station were available for these comparative studies, which made no pretext of simulating a natural behavioral situation. All of the released birds react to similar stimuli and follow similar courses, thus providing an excellent opportunity for documenting and comparing maximum flight speeds of a variety of species as they dash for cover. Wind speed and direction are readily measured at this low level of flight, so still another variable can be controlled.

The sound spectrograms on the opposite page were made from eleven species of birds from a variety of habitats, including woods, water, and shore, and illustrate information that can be gained from this field technique. Each sound spectrogram portrays the radar echo received during a brief segment of a bird's flight (up to 2.4 seconds in length). A series of these graphs, made at adjacent time intervals, record as much of the echo as is needed to understand each flight pattern and speed. Most of the graphs reproduced here are of maximum speeds. In each graph, the fundamental frequency of the radar echo is represented by the lowest horizontal lines; the other lines are its overtones. The vertical, or frequency, scale is marked off in intervals of 1,000 cycles per second, and has been adjusted for accuracy according to the 440-cycle frequency of the "A" pitch pipe recorded before and after each test. This standard reference frequency and its overtones appear at the beginning of each graph.

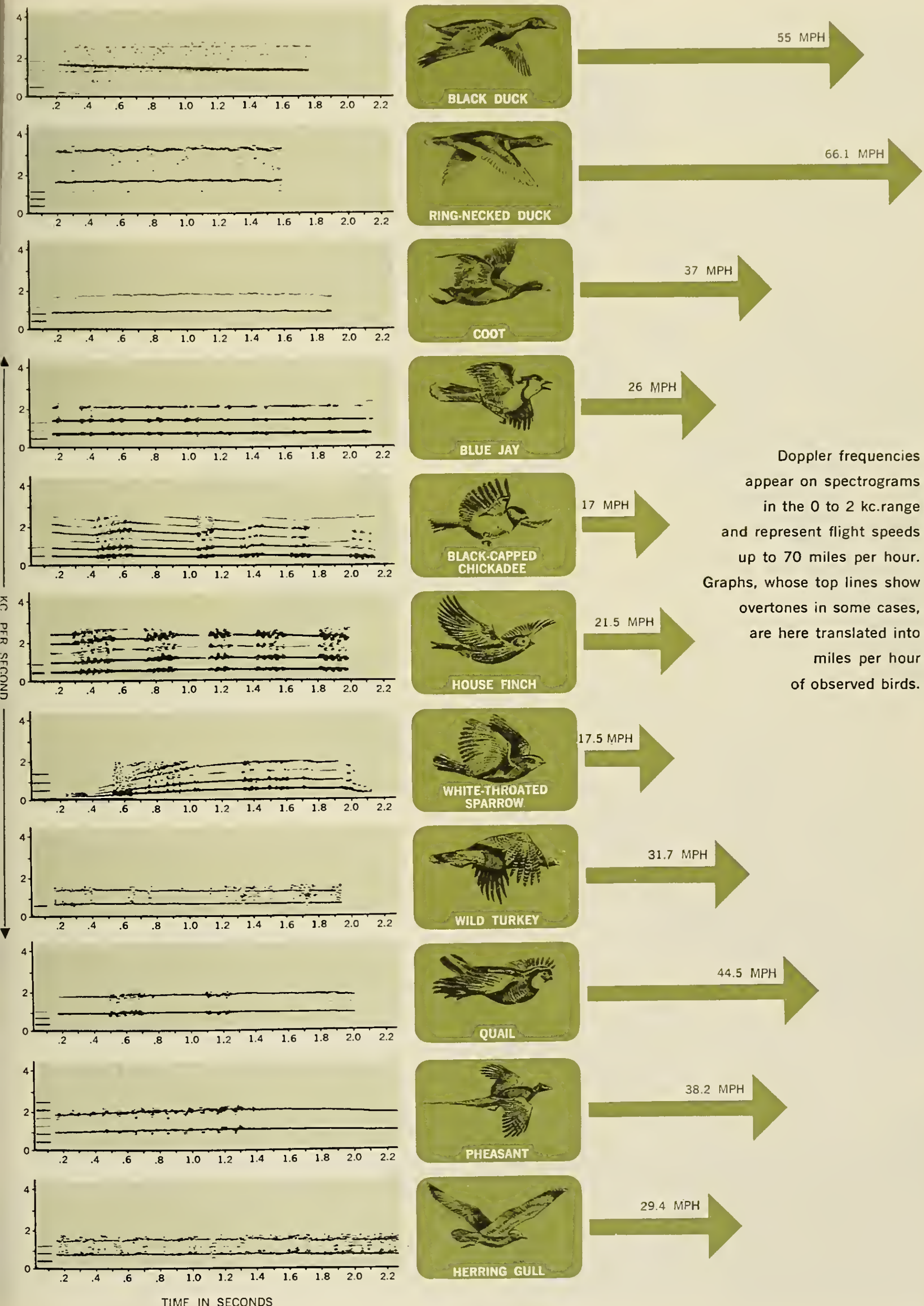
Dr. Lanyon, Assistant Curator in the Ornithology Department, The American Museum, is conducting population studies of the resident and migratory birds of Long Island.

The maximum flight speed achieved after release by a black-capped chickadee *(Parus atricapillus)* was 17 miles per hour. Its flight pattern is marked by periodic bursts of wing activity, which interrupt the otherwise steady radar echo. Each of these periods of activity results in a slight increase in the bird's over-all speed—as much as two miles per hour at one point. A white-throated sparrow *(Zonotrichia albicollis)* was able to reach a safe perch within two seconds after release, during which time it accelerated to a top speed of 18 miles per hour. The larger, more powerful blue jay *(Cyanocitta cristata)* reached a top speed of 26 miles per hour before reaching cover. Its wing activity is also registered on the graph.

The Doppler radar unit holds promise for determining the flight speeds of upland game birds whenever flight patterns can be predicted. Bobwhite *(Colinus virginianus)* were successfully tracked in my preliminary field tests with the aid of hunting dogs. After the dogs had located a covey, and while they held their point, the radar equipment was moved into a strategic position from which flushed individuals could be tracked. Two bursts of wing activity in the graph reproduced here increased a bobwhite's speed to 45 miles per hour. It will surprise no one who has hunted wild turkey *(Meleagris gallopavo)* that these large birds, cumbersome as they may appear, are capable of respectable speeds. A drove of over 30 birds baited into a woodland clearing near Tallahassee, Florida, afforded me a superb opportunity to select an individual with a suitable radial flight, and it attained a maximum speed of 32 miles per hour after being flushed. Game farm pheasants *(Phasianus colchicus* variety) flying "under fire" at a private hunting club provided still another situation where this equipment could be conveniently used. The spectrogram included here illustrates that portion of the pheasant's flight at which rapid wing activity ceases and the wings are "set" for a prolonged glide into cover. A maximum flight speed of 38 miles per hour was reached at the beginning of that particular glide. Most of the pheasants tracked had top speeds of from 40 to 45 miles per hour. The maximum speed determined was 48 miles per hour. There was no ground wind to complicate the upland game bird recordings.

A lake shore or an ocean beach provides another location where the radar unit can be used to good advantage. Shore birds, gulls and terns, and waterfowl can be tracked as they move up and down the water's edge. The herring gull *(Larus argentatus)*, whose flight pattern is illustrated, maintained a rather consistent speed of 29 miles per hour in its leisurely patrol of a beach on Long Island Sound. There was a cross wind of less than five miles per hour during this particular flight. On other occasions, I was able to operate the equipment from blinds and track wild ducks as they approached or flew away from my vantage point. In this manner, I recorded the radar echo from a black duck *(Anas rubripes)* as it came into the marsh for the evening. The spectrogram shows a deceleration from 55 to 44 miles per hour within a brief 1½-second time interval. The fastest bird tracked in the tests was a ring-necked duck *(Aythya collaris)* on its wintering ground in Florida. The radar echo from this individual indicated a speed of 66 miles per hour, which was attained in a cross wind of eight miles per hour.

Obviously, these preliminary tests have only begun to reveal the Doppler radar unit's potential to ornithologists, and there is certainly nothing definitive about the findings revealed here. But just as modern technology is now being used to document the speed of vehicles on our highways, it would appear that similar instrumentation has great possibilities for eliminating the element of speculation and conjecture in determining the flight speed of many species of birds.



Doppler frequencies appear on spectrograms in the 0 to 2 kc.range and represent flight speeds up to 70 miles per hour. Graphs, whose top lines show overtones in some cases, are here translated into miles per hour of observed birds.

Giraffe Movement and the Neck

Unique structure facilitates the animal's changes of position

By Anne Innis Dagg

The giraffe's long neck permits the towering animal to browse on the leaves of tall trees, which other herbivores cannot reach, and also allows the giraffe to spot enemies long before they are visible to shorter creatures. But my observations of giraffes at Klaserie, in South Africa's eastern Transvaal, indicate that besides these obvious functions as lookout tower and feeding adjunct, the animal's neck is a powerful aid to locomotion and fighting. It may propel the head in a hammer-like blow, or it may help the giraffe rise from a drinking or lying position, and aid in the walk, gallop, and jump. Yet despite its great length, this neck has only seven vertebrae. Each bone is very long, but the total is the same as in other mammals.

When a cart horse drags a heavy load, the animal thrusts its head and neck forward at each step to help pull the weight. The horse's neck also moves forward and back slightly even when the animal walks without a load, as does the neck of the giraffe. Because the giraffe's neck is so much longer and its head rather heavier than the horse's, the effect is much more pronounced. This is especially true of the eighteen-foot-high adult males, with skulls that weigh considerably more than those of the smaller females. It is least true in young giraffes, the necks of which are relatively half as long as the adults'—about one-sixth the total height of the calf.

Although the rhythmic neck movements of horse and giraffe can be roughly compared, the manner of walking is dissimilar. The horse, like

Giraffes in wild, *left* and *above*, have lofty outlook on their surroundings. Long neck allows animal to browse at levels beyond reach of shorter herbivores, to see far-off enemies, and to perform various bodily movements most effectively.

To DRINK, a giraffe spreads its forelegs slightly, then bends the front knees and lowers head and neck to water. Stance renders the giraffe vulnerable to attack.

most hoofed animals, moves its legs alternately, the right hind leg touching the ground just after the right foreleg leaves the ground to begin its stride forward. Often the timing is so close that it seems the hind foot must step on the forefoot. Meanwhile, the left legs are completing the same movements, but out of phase, so that the left foreleg is in the air nearly at the same time as the right hind leg.

The slowest walk of the giraffe resembles that of the horse, with three legs usually supporting the animal at one time, but as the giraffe increases its speed, the gait becomes a pace in which the legs on either side move forward together. The two right hoofs hit the ground at nearly the same time, then the left legs move forward as a pair. In the pace of both horse and giraffe the sequence of footfalls is the same—left hind, left fore, right hind, right fore—but the horse's hoofs hit the ground in regularly spaced beats, while the giraffe's two left hoofs, and later the two right hoofs, touch ground almost together. In the pace, the giraffe's weight is alternately supported by the left legs and then by the right legs during each stride, but the body's great weight and inertia help the giraffe retain its balance. The pace also prevents the long, closely set legs from interfering with each other, as they might if the giraffe walked like the horse: the giraffe's body is shorter than the legs, whereas the horse's body is nearly twice as long as the legs.

As the giraffe paces, its neck and head move back and forth twice during each stride. They reach their farthest point forward just before the right legs touch the ground and again just before the left pair is set down. Thus, the forward impulse of the neck shifts the animal's center of gravity to the front and aids the advance of the body. As each pair of hoofs touches the ground, the head is drawn back again to decrease the giraffe's forward momentum and to prepare for the next frontal thrust of the neck.

THE neck movement is noticeable, and it is easy to record if tracings are made from a film of the profile of a pacing giraffe. When the angle is taken between the straight line of the mane down the giraffe's neck and the straight line of the back between the hump at the base of the neck and the rump, the angle can be plotted against the number of the film frame or, in other words, against time. Successive movie frames illustrate the giraffe's attitude at intervals of 1/16 of a second. Such a graph of the neck-back angle plotted against time forms a regular wavy line. Two complete waves equal one stride. The distance between two crests or two troughs of the wavy line equals half a stride. The wavy line reaches a crest when the neck is farthest forward: the angle between the neck and the back is largest, and the giraffe is about to set the two legs on one side of its body, say the right side,

RISING FROM GROUND is done in stages with help of neck. Starting from *left*, with neck erect, giraffe pulls neck to rear to gain impetus, then raises body onto foreknees on neck's forward swing. Neck is brought back briefly, then

on the ground. At the next crest the animal is in the same position, with its neck stretched forward after having completed half a stride, but this time the two *left* legs are about to be put down. Between the crests, the neck has been drawn back as the animal begins to move two legs forward, and thrust forward as the legs complete the step.

Adult giraffes exercise little. They wander among the scattered trees to browse and they travel about once a day to the nearest drinking water. The young are more active. If alarmed or stampeded, however, even adults will break into a gallop. When they pace at about ten miles an hour, a complete stride takes approximately two seconds. When they gallop at thirty-five miles an hour, a stride takes only half as long to complete, even though a full gallop stride occurs between the two crests on the graph. This is because there are no separate right and left phases, as in the pace.

In the gallop, the giraffe's legs come together under the animal during each stride. The animal pushes off from the ground with the forelegs, moves through the air with front and hind legs spread apart, and lands first on its hind legs. As the legs come together beneath the animal, the hind legs touch the ground slightly before the forelegs, but no two hoofs touch simultaneously. Thus, four separate impacts can be distinguished for every stride.

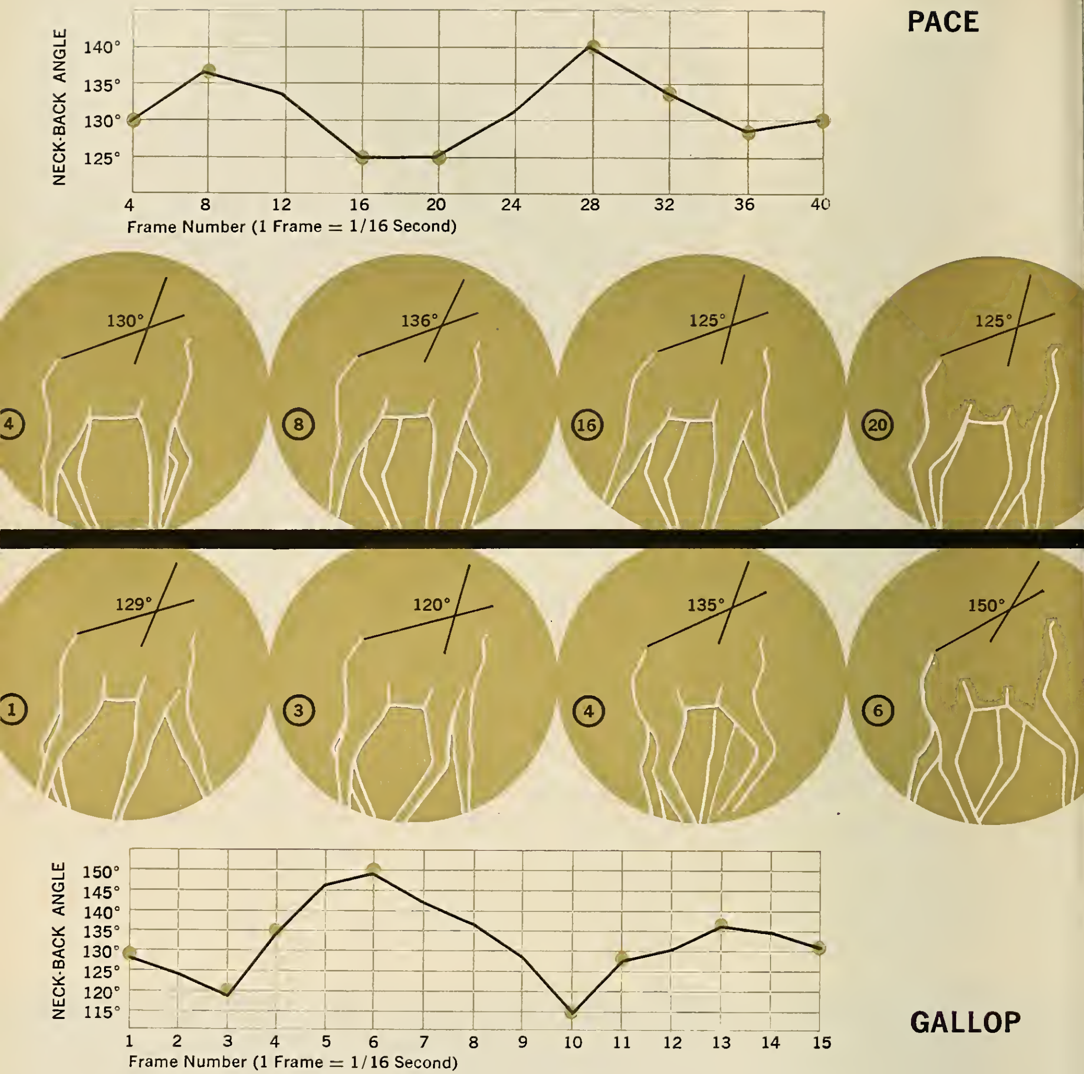
The oscillation of the neck is even greater in the gallop than in the pace. The neck's forward motion ends as in the pace—in time with the lunge of the body and just before the hoofs hit the ground. The neck arches back and forth, its impetus pulling the body forward during the frontal thrust.

AN ALTERNATE POSITION for drinking is shown by the giraffe at left. Forelegs remain straight as the animal spreads them in series of spasmodic movements.

NECK movement is particularly useful when a giraffe begins to gallop from a resting position. In somewhat less than half a second the neck-back angle may increase from 115° to 165°, with the giraffe's weight so placed in respect to the forequarters that the animal can plunge forward instantly. Only a second or two after standing still, the huge body is moving—a considerable feat for an animal that weighs rather more than a ton.

Although giraffes and other game once wandered freely on the African veld lands, farmers have begun to put up cattle fences on their property. At first the giraffes ignored them. If they could not go around a fence they went through it, scattering broken wires behind them — to the indignation of the farmers who allowed the giraffes to stay on their land only on sufferance. Within three or four years, however, the giraffes, in South Africa and Kenya at least, adapted to the fences. They have learned to jump over them, although the young are too small to do so and occasionally an adult becomes confused. One female giraffe in South Africa jumped over a fence with the rest of the herd, leaving her newborn behind. She paced along the fence

swung forward sharply to raise hindquarters over the rear legs. Withdrawing neck again and shifting weight from the front legs allows the giraffe to straighten them. The series ends with the giraffe standing in a normal, stable stance.



for at least sixteen hours, apparently unable to rejoin her young, which wandered into the bush veld and was not seen again. It presumably starved.

However, most adults can pass over a fence 4 feet 6 inches high even if a hind foot catches briefly on the top wire. To jump over a fence, the giraffe first hoists its forefeet over the fence together, pulling its neck — and therefore its weight — far back onto the hind feet to do so. After it has regained its balance, it moves forward with the wire under its stomach and then brings its hind legs over the fence, this time throwing the neck forward so that the weight shifts entirely onto the forefeet. Such jumps take about a second.

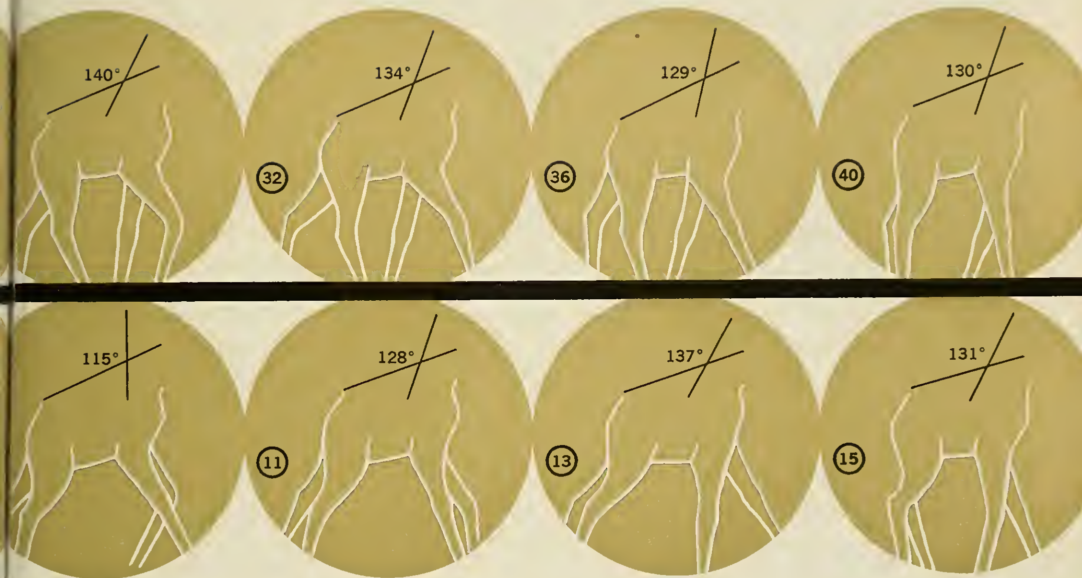
Overcoming fences is only one way in which giraffes have adjusted to civilization. They have also learned to drink at cattle water troughs, which some other game species will not do.

Whether drinking from a cattle trough, a river, or a natural water hole, the giraffe has difficulty lowering its head to the water level. The neck may be long, but so are the legs, with the forelegs slightly longer than the hind. In most other ungulates the hind legs are the longer ones.

To drink, giraffes either spread their straight forelegs farther and farther apart in jerks as they lower the head, or spread the forelegs somewhat and then bend the foreknees to reach the water. Either stance is ungainly, and renders the giraffe helpless if a lion should choose such a time to attack — as often happens.

Perhaps in compensation for this vulnerability, the giraffe can regain an upright position in the surprisingly short time of one second by snapping

CO-ORDINATES ON GRAPH relate neck-back angle of a pacing giraffe to intervals of time. Sketches showing the relative positions of feet, neck, and back at key points in stride are numbered to correspond to positions plotted on graph.



GIRAFFE MOVEMENTS in gallop are shown below motions in the pace to permit comparison. A pacing giraffe advances by moving left legs forward together, then the right legs. In gallop, legs are bunched under the animal, then spread.

its neck back and simultaneously straightening and pulling the forelegs under it. Some early physiologists predicted that a giraffe would faint if it did not raise its head slowly and gently from the drinking position, giving the circulation of blood to the brain adequate time to adapt to the changing level of the head. It is known now that the giraffe's circulatory system is too well equipped with valves in the arteries and veins, specially adapted vessel walls, reservoirs for blood in the head, and alternate blood routes to the brain to be upset by changes in head level and, therefore, in blood pressure, no matter how sudden the movements.

Even more difficult for the giraffe than rising from a drinking position is getting up after lying down—an attitude in which most giraffes sleep during the night and many rest during the day. If a giraffe falls into a deep sleep it lays its neck along its back with its head nestled on its flank, but such sleep lasts for only four or five minutes at a time, totaling about half an hour a day. During most periods of lying down, the giraffe's head and neck are upright. In captivity some also sleep briefly with their necks and heads stretched flat on the ground. However, I know of no giraffes observed in this position in the wild, except for two males knocked unconscious during one of the frequent head-hitting encounters in which male giraffes indulge.

Even a giraffe lying with head and neck erect must exert considerable effort to rise. First the animal throws its neck backward to gain impetus. It then hoists itself onto the foreknees while the neck swings forward. It holds this awkward stance for nearly a second to regain equilibrium, then swings

Legs straight and spread apart, as in a drinking posture, small giraffe, right, grazes with herd. Animal near it bends front knees to reach ground.

Neck propels head in a hammer-like blow as two giraffes fight. Such contests occur so frequently that hair is worn from horns of all but youngest males.

the neck slightly backward and vigorously forward to raise the rear quarters over the hind feet. The animal then pauses about a second while stabilizing itself. The neck is drawn well back again, removing weight from the forelegs. Now the giraffe can shift from kneeling to standing on the forelegs.

Perhaps the most spectacular use of the neck occurs in the giraffes' head-hitting bouts. These contests between bulls are so frequent that the hair is worn off the horns of all but the youngest males, a characteristic that makes identifying a wild giraffe's sex very easy. The more serious fights are usually between two adult bulls, but they may include a third male or even a baby giraffe on occasion.

I watched one battle from a car parked sixty yards from the two opponents. At first they stood side by side, looking straight ahead. Occasionally one bent its head toward the ground, as if bowing; then the other male

Mrs. Dagg observed and filmed wild giraffes near Kruger National Park in the Union of South Africa during 1956 and 1957. She is now studying at the School of Graduate Studies of Canada's University of Waterloo.

bowed, too, keeping its head opposite that of the first giraffe. Suddenly the first male brought its head back and sideways a short distance and then whipped it with terrific force, horns leading, at the belly of the second giraffe. The giraffe tried to dodge the blow by stepping aside, but was not quick enough. I could hear the impact clearly. The second giraffe retaliated by aiming a head blow at the other's legs: although the animal nearly missed, its horns just caught the opponent's foreleg under the knee, knocking it out from under the giraffe. Then the first giraffe made a wild lunge at the other. It missed entirely this time. The return blow by the second giraffe was meant to be an uppercut, but the first male raised its nose very high, with neck arched back, so the rap merely glanced off the elevated chin.

After a short exchange of hits and misses, the bulls shoved each other with their bodies. One managed to push the other against a tree before dodging behind it. Then they circled round the tree, striking at each other's flanks when the opportunity arose. After ten such circuits, one male walked over to a bush. The other followed and the two butted against each other with their heads; then they rubbed their necks together. Soon one began to feed at a bush while being lightly pounded by the other animal; presently they were browsing in apparent peace.

Such encounters occur daily, whether or not females are present to incite the males. Occasionally one opponent may be knocked unconscious or be cut so badly that it bleeds, but despite the heavy heads and sturdy horns of the males, and the terrific speed with which the long neck can propel the head, such casualties are rare.

It is evident that the giraffe uses its neck mechanically to a great extent. The long neck not only enables the giraffe to browse more selectively and to watch more easily for predators, but it also is a necessary part of the animal's over-all locomotor mechanism.

Long reach of adult nuzzling young demonstrates additional use for neck.

SKY REPORTER

Radio astronomy proved that earth is part of a spiral galaxy

By Simone Daro Gossner

When John Herschel went to the Cape of Good Hope in 1834 to extend to the Southern Hemisphere the studies of nebulae undertaken by his father, he was awed by the beauty of its rich Milky Way fields. The nebula surrounding the star that now bears the name Eta Carinae (see photograph at *left*) caught his eye particularly because of its proximity not only to dense star fields, but also to some of the most intensely black regions of obscuring dust.

Carina (the Keel), along with Vela (the Sails), Puppis (the Stern), and Pyxis (the Compass), is a modern subdivision of the enormous constellation of Argo. A familiar sight to the ancient Greeks who had named it for Jason's ship, Argo receded gradually into the southern heavens because of the continuous displacement of the equinoxes (Natural History, January, 1962). Now only the constellation's northernmost stars may be seen, barely rising above the southern horizon at our latitudes.

The nebula around Eta Carinae was first observed and catalogued by Abbé Nicolas de Lacaille in 1752. However, the cumbersome system of designations that he adopted in his catalogue proved so impractical that it was little used and was soon forgotten. It required enthusiastic description by John Herschel to bring Eta Carinae once again to the attention of astronomers. The nebula, a vast cloud of luminous gas streaked by lanes of dense obscuring dust, lies about 4,000 light-years away in one of the inner spiral arms that coil around the nucleus of the Milky Way.

Until a decade ago, any reference to the spiral structure of our own Galaxy would have been voiced with some hesitation. At the end of 1924, Edwin Hubble, of the Mt. Wilson Observatory, proved conclusively that the sky objects we now call galaxies were indeed "island universes," vast star systems at almost inconceivable distances. Ever since that time, there has been no doubt in any astronomer's mind that our own star system is an island universe in its own right. Unfortunately, galaxies vary so much in shape—ellipticals, spirals, barred spirals, irregulars—that it had not been possible to tell with certainty the category to which our system belongs. Being embedded in it, we see our star system outlined on the celestial sphere as the belt we call the Milky Way. If by some feat of levitation we could have transported ourselves to a distance of, let us say, 200,000 light-years, we would have had a good outside view, and the problem would have been solved immediately. But earthbound astronomers had to rely at first on comparisons, deductions, and educated guesses.

As galaxies were studied in greater detail, it became apparent that certain features were common only to galaxies of a given type. Ellipticals appeared entirely devoid of interstellar gas and obscuring dust: hot blue stars seemed absent, too. On the other hand, bright gaseous nebulae, dust lanes, and hot stars were detected in abundance in the whirling arms of nearby spirals such as the Great Galaxy in Andromeda. It was cautiously concluded that the Milky Way was also a spiral, probably similar to Andromeda, because the two had so many features in common.

The first breakthrough in demonstrating the spiral nature of our home Galaxy occurred in 1951 when W. W. Morgan, of the Yerkes Observatory, plotted the space positions of a number of hot blue stars in our system. He had chosen those particular stars because they were of a kind found exclusively in the spiral arms of other galaxies. The graph showed unmistakably the characteristic curvature of two parallel segments of a spiral. The segments were short and the graph looked dull, but astronomers had been given the first shred of evidence that their theories were correct.

There was little hope that additional corroborative data could be obtained by observing with optical telescopes, because individual stars in our Galaxy are visible to a distance of only a few thousand light-years. Beyond that, they are hidden from view by intervening dust. However, the few years that followed Morgan's discovery saw the spectacular development of radio astronomy, with radio telescopes that can observe radiation in wave lengths that are not blocked by interstellar clouds. By observing the radiation of neutral hydrogen, which occurs in great abundance in spiral arms, radio astronomers were able to draw a detailed map of about five-sixths of our Galaxy. The spiral structure of the Milky Way ceased to be a matter of speculation and became an indisputable reality.

A spiral galaxy has a well-defined nucleus of bright, tightly packed stars. When viewed edge-on, the nucleus forms a noticeable bulge in the otherwise flat disk of the galaxy. No such feature could be found in the Milky Way by ordinary optical and photographic means. Yet astronomers had noted that the southern Milky Way exhibits much denser star fields than its northern counterpart. Tracing it from Monoceros through Puppis, Vela, Carina, Crux, Centaurus, Norma, Scorpius, Sagittarius, and Scutum, the astronomers were struck particularly by the steep rise in stellar density that they observed in Sagittarius. If the Milky Way had a nucleus, it had to lie in that direction.

Although hidden from view by intervening gas and dust clouds, and thus invisible when using conventional viewing means, the nucleus had to yield to two of astronomy's modern methods of observation: the radio telescope and infrared photography. In both instances, the observed radiation is of such low frequency—that is, long wave lengths—that it travels unhampered through the obscuring medium. Infrared photographs of the Sagittarius region, taken with a wide-angle camera, look strikingly like the central regions of some edge-on galaxies, nucleus bulge included. Radio observations similarly recorded the nucleus' radiation.

The dissimilarity between the southern and northern Milky Way is attributable mainly to the solar system's great distance from the center of our Galaxy. The northern Milky Way shows principally its thinner, outer spiral arms.

THE SKY IN AUGUST AND SEPTEMBER

From the Almanac:

First Quarter	August 8, 10:55 A.M., EST
Full Moon	August 15, 3:10 P.M., EST
Last Quarter	August 22, 5:27 A.M., EST
New Moon	August 29, 10:09 P.M., EST
First Quarter	September 7, 1:45 A.M., EST
Full Moon	September 13, 11:12 P.M., EST
Last Quarter	September 20, 2:36 P.M., EST
New Moon	September 28, 2:40 P.M., EST

The sun will cross the equinox September 23, 7:35 A.M., EST, and autumn will begin in the Northern Hemisphere.

For the visual observer:

Mercury, in the evening sky, will be too close to the sun to be seen in early August. It will remain unfavorably placed during the rest of that month, setting 45 minutes after sunset on August 15, and one hour after on August 31. It will reach its greatest eastern elongation on September 10, but it may be difficult to see, as it is so low above the western horizon. The planet will set 45 minutes after the sun on September 15, and at sunset by the end of September.

Venus, also in the evening sky, will be conspicuous above the western horizon right after sunset in August and September. It will set about two hours after the sun on August 1, one hour and 45 minutes after on August 15, 90 minutes after on September 1, and 90 minutes after on September 30. The planet will be at its greatest eastern elongation (46°) on September 3. Brightness will increase from —3.8 magnitude in August to —4.1 by mid-September.

Mars, in Gemini (+1.2 magnitude), will rise in the northeast at 1:00 A.M., local standard time, August 1, 12:30 A.M. on August 15, midnight on September 15, and 11:45 P.M. on September 30. By the end of September, it will be nearly overhead by sunrise. On September 30, Mars will pass 6° S. of the star Pollux and should be found easily.

Jupiter, in Aquarius (—2.4 magnitude), will rise about 90 minutes after sunset on August 1, 45 minutes after on August 15, and at sunset on August 31. It will remain visible all night during that month. In September, Jupiter will have risen by sunset and will set at sunrise on September 1, 75 minutes before sunrise on September 15, and at about 3:00 A.M., local standard time, on September 30.

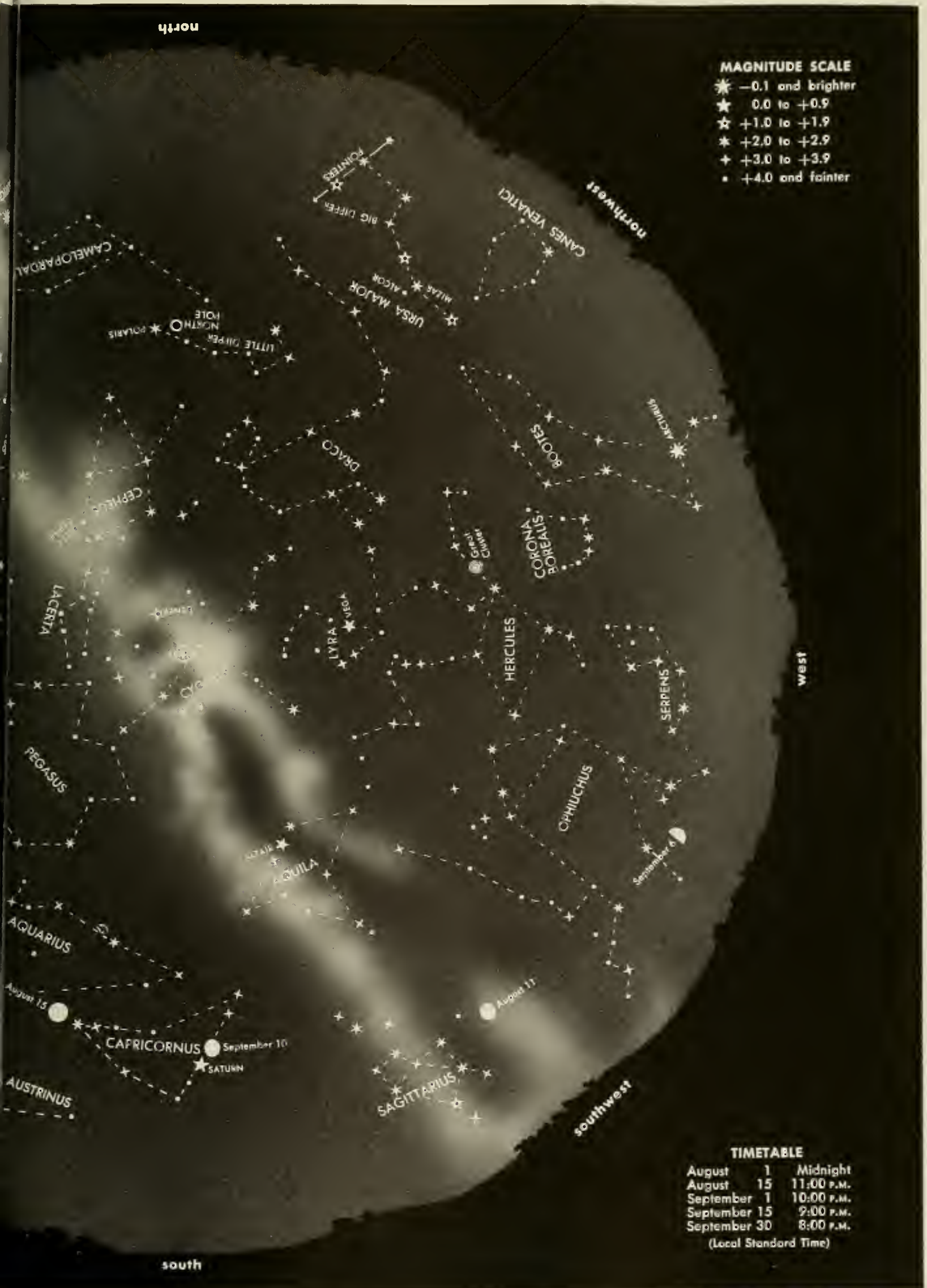
Saturn, in Capricornus, will have risen by sunset and will set at sunrise on August 1, 90 minutes before sunrise on August 15, at about 3:00 A.M., local standard time, September 1, 2:00 A.M. on September 15, and 12:45 A.M. September 30. Its brightness will decrease slightly from +0.4 magnitude in August to +0.6 in September.

The Perseid meteors, belonging to the most favorable shower of the year, will reach maximum frequency on August 12. Usually they can be seen for about a week before and after that date. Although a few Perseids may be expected in the early evening hours, they are considerably more frequent after midnight. Under the most favorable conditions, as many as 50 meteors per hour may appear to a single observer when the shower is at its maximum. This year the maximum will occur three days before full moon, and the fainter meteors may escape detection.

The penumbral eclipse of the moon, on August 15, will not be visible to observers situated in the United States.

On the preceding pages, MRS. GOSSNER offers the seventh article in her 1962 series—a survey of the celestial sphere.

To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.



MAGNITUDE SCALE
- −0.1 and brighter
- 0.0 to +0.9
- +1.0 to +1.9
- +2.0 to +2.9
- +3.0 to +3.9
- +4.0 and fainter

TIMETABLE

August	1	Midnight
August	15	11:00 P.M.
September	1	10:00 P.M.
September	15	9:00 P.M.
September	30	8:00 P.M.

(Local Standard Time)

JAPANESE BEETLE LARVA's slender sense organs are seen in front view, *above*. Grub uses mandibles beneath its shiny upper lip to sever roots. In view, *opposite*, ingested soil renders outer edge of abdominal segments nearly invisible.

MULTIPLYING MIGRANT

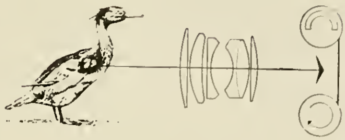
Japanese beetle thrives despite attempts to eradicate it

THE JAPANESE BEETLE, in its larval and adult stages, destroys millions of dollars in plants annually in the United States. The voracious adult beetle tears and eats leaf tissue, fruits, and vegetables with the aid of two laterally attached mandibles. During the summer months, the female burrows just under the surface of the soil to lay its eggs, from which the destructive larvae emerge in about 14 to 21 days. The larva, or grub, uses its mandibles to sever plant roots in its subterranean environment and forces the segments into its alimentary system. The grub works its way deeper into the soil, where it winters, returns almost to the surface for a week or so in the spring to pupate, and finally emerges from the ground as an adult beetle.

In 1916, several specimens of this handsome and then unfamiliar insect were found in a New Jersey plant nursery. Identified as the Japanese beetle, *Popillia japonica* Newman, it was thought to have been brought to the United States on plant roots about 1912. Natural predators kept the green and bronze menace under control in Japan, but in the United States it had no effective enemies and multiplied rapidly. Despite Federal quarantines on interstate movement of materials by which the insect might be transported, it has spread from the eastern states, where it was first found, to states in the south and west to the Pacific.

NATURE and the CAMERA

Exposure choice is a creative decision



By David Linton

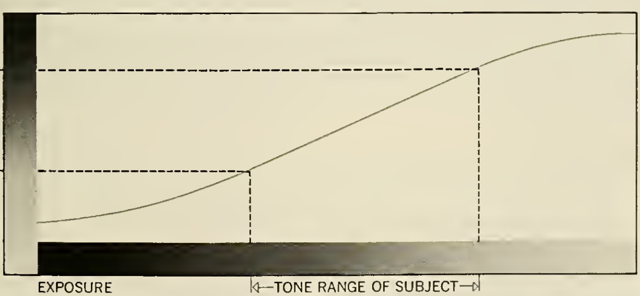
From time to time this column turns from the applications of photography in nature study to consideration of photographic fundamentals. This month we will discuss the process by which the image formed in the camera (see article on focus, Natural History, November, 1960) is translated into a corresponding, but not identical, image on film.

Exposure is the most convenient name for the process. It involves much more than simply deciding how to set the camera's controls. Properly used, exposure is one of the tools the photographer has to make the pictures say what he wants to say. We have only to think of terms like somber, gray, dull, and shadowy, or bright, sunny, sparkling, and luminous to realize the emotional connotations of light. In photographs, the rendering of light is controlled by exposure.

This is not to say that a dull, dark scene can be made to look scintillating by proper choice of exposure. There are limits. But the appearance of light in photographs, and with it the mood, is subject to more control through exposure than most photographers realize. There is no such thing as *the* correct exposure for a picture—there may be many different exposures that will yield an acceptable print without too much manipulation during printing. The choice of one or another is part of the creative process and is not a technical matter at all. But the photographer must understand the technical process in order to use it creatively.

All the colors and degrees of brightness in the original camera image are recorded on film in the same form—as lesser or greater concentrations of silver grains, which render the film more or less transparent after it is developed and fixed. This is true even if the film is color film, because color film does not record images in color. It records a set of three black-and-white images, one on top of the other, corresponding with reasonable accuracy to different parts of the spectrum in the original scene. The color is reconstructed later in processing. Even with films that yield positive transparencies the original images are black-and-white negatives, and the processing not only adds color but also converts the negative images to positives. All films respond in fundamentally the same way when they are exposed.

Modern films (except those designed for special purposes) have considerable latitude. That is, they will produce acceptable images from a fairly wide range of exposures. The images are not identical, however. The image produced by a generous exposure does not look the same as the image produced by a scant exposure, even though both may be printable. The reason is that the response of films to light is not linear. There is no direct and uniform relation between the amount of light falling at one point on the film and the resulting density of silver. The relation is fairly uniform within certain limits, but beyond those limits the film cannot follow. The mathematical expression of the relation is a response curve (*below*) that has a straight portion in the middle and a curve at each end. The upper curve is called the shoulder, the lower curve is called the toe. Only exposures falling on the straight part of



Response Curve shows exposure's relation to density of negative. Only exposures on straight portion of curve will reproduce accurately the appearance of the subject.

WARM, BRIGHT MOOD of beach scene at Cannes derives from short tone scale comprising many light tones and almost no deep black.

the response curve will be reproduced accurately. This is not necessarily a disadvantage, because the finished product —a photographic print, transparency, or a printed page—usually has much less range from light to dark than has the original scene, and all the tones of the original must in some manner be compressed into the range of the final picture. The range of the film is usually less than the brightness range of the subject, but greater than the range of the paper print. Thus, there is a two-stage compression of the tonal range from scene to negative and again from negative to print. The extent of compression, and also the region (highlight or shadow) where most of the squeezing occurs, can be controlled by proper selection of exposure and development.

DAVID LINTON's by-line has appeared under photographs in all the nation's leading magazines. His camera column is a regular feature on these pages.

The human eye and mind can accept an enormous range of light intensities—far more than any film can record. The photographer must allow for this in selecting his exposure. He must recognize that if he photographs a scene in which the sun sparkles on the surface of a stream running through a dark forest, no film can preserve as much detail in both the bright reflections and the dark shadows as the eye can see. The photographer must choose to emphasize one or the other, or sacrifice some of each.

Occasionally a subject has a shorter range of tones than is needed to produce a normal print. In that case, exposure and development are altered to expand, instead of compress, the tone range.

OLD-TIME photographers used to pride themselves on their ability to guess correct exposures. They generally worked under fairly uniform conditions, however, and used only one or two kinds of film. A light meter is absolutely indispensable for the wide range of materials and picture-taking conditions encountered today. But the old-timers' judgment is not obsolete; it is still needed to interpret the meter readings.

Light meters used for ordinary picture taking are all of the integrating type, which means that the reading they give is an over-all, average intensity for all the light coming from the area they cover. The better meters usually cover an angle (called the angle of acceptance) roughly equal to the coverage of a normal focal length lens. Such a meter will give a workable exposure for a large proportion of pictures if it is simply pointed at the subject. It is more helpful, however, if it is used at close range to measure the lightest and darkest parts of the subject. The photographer can then determine the best intermediate exposure for that particular picture.

One type of integrating meter is called an incident light meter because it measures the light falling on the subject, instead of the light reflected by it. To base exposures on this information, the meter assumes an average reflectance for the subject, just as the reflected light meter assumes an average distribution of light. However, the incident light meter cannot be used to measure the lightest and darkest parts of the picture, and frequently it cannot be used to measure the light falling on the subject, either, because the subject is not accessible—a

PREDOMINANT DARK TONES and absence of bright highlights lend a somber quality to photo of smugglers off island of Saint Pierre.

mountain in the distance, for example.

Meters that are built into the camera are not a good choice. The whole camera must be moved to take readings at different points, and the small size imposed on such meters limits their sensitivity.

Whenever the meter cannot read the subject directly, it can be used to read something else of about the same color and brightness as the subject. The photographer's hand is often used as a substitute for a person's face.

AVERAGE, over-all meter readings are particularly unreliable where there is a great difference in brightness between subject and background. A skier seen against a snow-covered hillside, or a sunlit wildflower in a dark forest will not be properly exposed if exposure is based on an average reading. Similarly, although it is less apparent to the eye, the sky on an overcast day is many times brighter than any object on the ground.

Under such conditions, readings must be taken so as to measure the subject, not the background. In fact, a photographer would not go far wrong if he adopted, as a rule of thumb, the practice of basing exposure solely on the brightness of the subject and ignoring the surroundings.

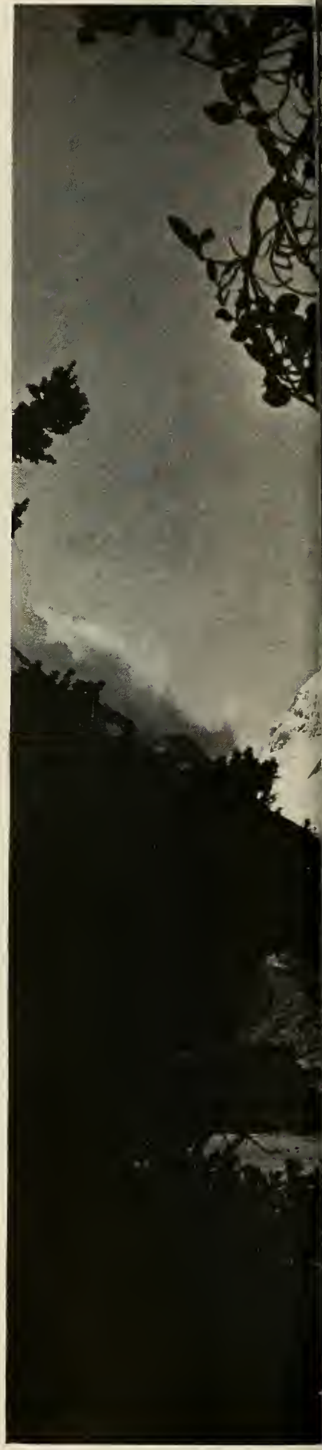
On a higher level of complexity are pictures in which the subject itself has a range of tones so great or so small that the exposure must be altered to accommodate it. If the range is very great, the photographer may have to lose some separation in either the highlights or the shadows. They may fall above or below the range in which the film can record them without distortion, or, to put it in mathematical terms, above or below the straight-line portion of the curve.

Values lying on the straight portion will be compressed or expanded according to the slope of the line. Various films and developers produce different amounts of slope, or contrast. So do differences in developing time. Extending development increases contrast and also increases the density of the image, bringing it closer to the shoulder, where the line is no longer straight and tones will not be adequately separated. This effect is called blocking up of the highlights.

It follows, therefore, that a subject with a short tonal range should have a scant exposure and generous development. Similarly, a subject with a great range of tones should have a generous exposure and scant development. The extent to which exposure and development can be varied will depend on the film and developer used. Characteristic curves for most common film and developer combinations are published in photographic handbooks.

With small sizes of film, where there are many exposures on a roll, it is seldom convenient to give different amounts of development to different frames. This is, in fact, one of the few persuasive arguments in favor of the larger camera that uses sheet film. But the cost of film is a small item in the picture-taking budget, and it is worth while to use several rolls instead of one and develop them differently, as the subjects require. It is possible to take partially used 35 mm. film from a camera, put it back later, and use the remainder. One camera even has a small knife inside to cut off the used portion of the film so the rest can be exposed and developed differently.

Exposures may be computed with such precision that every spot in the scene will be represented by an exact, predetermined shade of gray in the final print. Ansel Adams is the author of a widely admired system for doing this. It is too



FILTER WAS USED for photo of Mt. Cook to render the scene as it appears to the eye.

time-consuming for photographing live subjects. however, and even with landscapes there would be a danger, for most photographers, that the sun might set before the exposure computation was finished. Fortunately. such precision is seldom necessary. Films do not record colors as the eye sees them, which is just as well. because the eye has an amazing ability to adapt to changing light conditions. If films did the same it would be impossible to predict their behavior. As it is, we know that panchromatic black-and-white film (the only type in general use now) is more sensitive to blue than is the human eye, and is sensitive to ultraviolet, to which the eye is not sensitive at all. Thus. blue areas such as the sky appear lighter in a photograph than they do to the eye. Areas rich in ultraviolet, such as fog banks, overcast skies. and morning mist. will appear lighter and also more opaque.

The response of a panchromatic film in daylight will approximate that of the eye if a K 2 (medium yellow) filter is used. which requires doubling the exposure. Blues can be made still darker with an orange or red filter and greater increases in exposure. The exposure increase must be applied judiciously because too much exposure will compress highlights and may thus negate the effect produced by using the filter.

Shadows on snow are actually blue. as close examination will reveal. and they contain much ultraviolet. too. To preserve them and thus show texture in snow. a yellow or orange filter must be used. Most shadows cast by the sun are lighted by blue light from the other side of the sky. and will appear too light without a correcting filter.

Colors that seem dissimilar to the eye may look alike in a black-and-white picture, and confuse or obscure the subject. Filters should be used to separate them. As a rule. a color will be rendered lighter by a like-colored filter and darker by a complementary one. Tables of filter recommendations for various subjects are available, and one can judge a filter's effect by viewing the subject through it.

FILTERS can be used with color film, too, and their action is fundamentally the same as in black-and-white photography. As mentioned earlier, the image on color film is a set of black-and-white images until the film is processed. But since the end product is going to be in color, the filters cannot be as heavily colored as those used for black and white. Color film is sensitive to ultraviolet. too. and a skylight filter should be used for overcast snow scenes, fog, and distant landscapes to reduce the washed-out effect ultraviolet produces. An orange filter for greater haze penetration will work, as it does in black and white, but since it turns the entire scene somewhat orange, a film balanced for warmer (more orange) light should be used. Such films are the "indoor" types balanced for use with floodlights. clear flash, or studio incandescent lamps. Each type has a matching orange filter, called a conversion or light-balancing filter that adapts it for use in daylight and also subdues haze. Of course. the orange filters for color are not so dark as those for black-and-white films.

Other color filters can be used to advantage to emphasize some colors and subdue others. Experience is the only guide in this, but acquiring that experience is an enjoyable pursuit. The use of filters in color photography need not be restricted to correcting illumination. It can, with practice, be a creative tool.

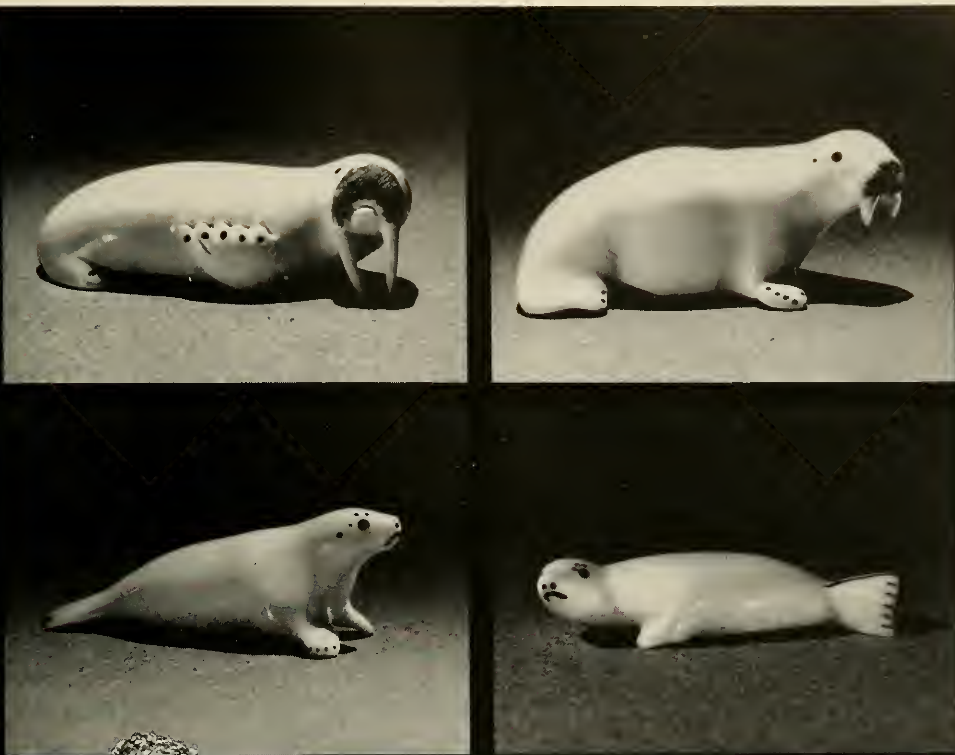
Film speed ratings are necessary as a basis for computing exposure, but they should not be taken too seriously. The methods of deriving numbers are standardized within different countries. but only for black-and-white films exposed in daylight. The American system is called ASA, after the American Standards Association. The British Standard (BS) is almost identical. The German system is called DIN, which stands for *Deutsche Industrie Normen* (not, as some wags have suggested. for *Das ist Normal*). All the systems are based on a standard exposure and standard processing of the kind most films get—that provided by the corner drugstore. Many professionals, whose films are developed individually, routinely use twice the standard exposure index.

ACTUALLY, it is possible to obtain a picture from any one of a wide range of exposures. For the very best picture. the exposure must be adjusted to fit the nature of the subject and the quality of the light. Whether this is done by varying the film speed or by interpreting the meter reading, the result will be the same. Subjects of high contrast will require more exposure than average; subjects of low contrast will need less.

Learning when and how to make these adjustments requires practice. The first step is to make several, varied exposures of each stationary subject that you photograph, and then study the results carefully. You may find the best picture is not the one that is made "by the book."

This list details the photographer, artist, or other source of illustrations, by page.

COVER—David Linton
3-4—Joseph Sedacca
10-21—William R. Coe except 13-bot. AMNH, after H. M. Gregersen
22-23—David Linton
24-26—Werner Jacobs
27—David Linton
28-37—Arline Strong
38-39—W. Bryant Tyrrell
40-43—AMNH
44-45—George Holton, from Photo Library
46-47—Anne Innis Dagg
48-49—AMNH, after Dagg
50—top, Halmi, from Birnback Publishing Svce., bot., C. A. Spinage, from Annan Photo Features
51—Ylla, from Rapho Guillumette Pictures
52—Harvard Observatory, Boyden Station, Bloemfontein, Rep. of S. Africa
54-55—Sky Map, after Henry M. Neely
56-57—Roman Vishniac
59—AMNH
60-63—David Linton



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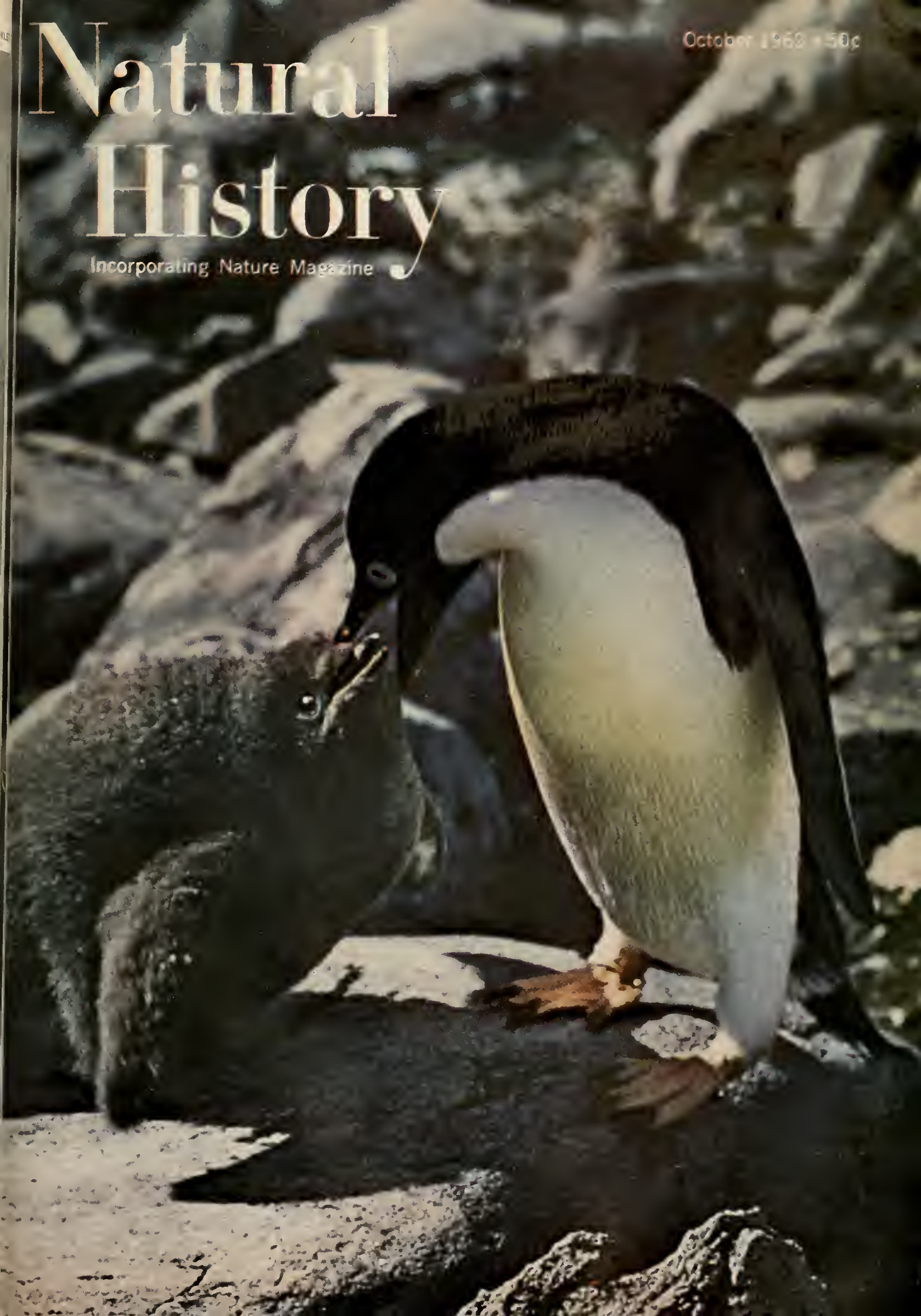
Natural History

Incorporating Nature Magazine



Natural History

Incorporating Nature Magazine

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COVER: The Adélie penguin, here feeding its enormous chick, traveled some 2,400 miles to reach the breeding grounds in Wilkes Land, where it was studied by Richard Lee Penney, an ornithologist whose interest centers on the manner in which voice recognition influences behavior. His observations and conclusions are illustrated with his photographs and begin on page 16. Incidentally, it is interesting to note that two Welsh words—"pen," or head, plus "gwyn," white—give the bird its name, which originally was that of the now-extinct great auk, to which this penguin bears a superficial resemblance.

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Reviews

New views from Pylos and architectural ethos

By Bernard Goldman

Mycenaeans and Minoans, by Leonard R. Palmer. *Alfred A. Knopf, $6.00; 264 pp., illus.*

While there may be a division of opinion in matters philological and interpretative, the decipherment of the Linear B tablets of the Minoan-Mycenaean people "may be accepted as in principle accomplished," as stated by no less an authority than the revised *Cambridge Ancient History*. The exciting account of the "cracking" of the 3,500-year-old script by the late Englishman Michael Ventris was told in these pages by his friend John Chadwick (Natural History, March, April, 1961). Now the story of this previously mute epoch in human history, which is the threshold of Western civilization, must be rebuilt on the basis of this new knowledge.

Leonard Palmer, Professor of Comparative Philology at Oxford University, has provided a detailed, readable survey of the later years of the Minoans and Mycenaeans as revealed by these newly translated Linear B texts. *Mycenaeans and Minoans* begins with a brief chapter on the location and identification of the site in the Greek Peloponnese that yielded hundreds of the inscribed clay tablets, followed by a review of the Linear B scripts. The size of this vast archive, found by the American archeologist Blegen, gives the site a position of key importance in the study of a heroic period in Mediterranean prehistory. Hence, Palmer sketches in the history of the site and details the evidence that permits its identification as Pylos, the capital of old Nestor—Mycenaean king of the Homeric epic.

From the mass of accounting contained in these tablets, the author extracts the basis for reconstructing the Mycenaean system of land tenure, the bureaucratic administrative organization of this warrior kingdom, its basically agrarian economy, and its gods and cults. Most dramatic is the tragic picture of those last days of the Pylian kingdom as deduced from the seemingly uneventful rolls of food and equipment distribution, the dispersion of people, and the reports of the activities of metalsmiths, masons, and sailors. For the tablets were written just as the tide of history drowned that proud warrior society—about 1200 B.C.—in what may have been a wave of Dorian people coming from the North.

Palmer proceeds from this local history of a late Bronze Age kingdom to the broader implications it holds for the prehistory of the eastern Mediterranean. Now, it is important to remember that until Linear B was deciphered, our knowledge of what happened in the Aegean area at that time was obtained primarily through the Homeric epics and the eloquent testimony of archeological remains. But Homer must be handled with care by the historian; there are many unanswered questions about the authorship, date, and accuracy of the *Iliad* and *Odyssey*. No matter how authentic the epics seem as they depict the culture of the Achaean heroes, the writing of the tales came many centuries after the people and events recorded. The impressive remains of Mycenaean art and architecture were seen within the massive walls of Mycenae and Tiryns. They told of proud feudal principalities, rich in gold and skilled craftsmen, capable of monumental building, and engaged in extensive trade.

Then, at the very beginning of the twentieth century, Sir Arthur Evans exposed the ruins of an earlier, aristocratic society that had built a multistoried Palace at Knossos on Crete. For over thirty years Evans fought with spade and pen to restore this civilization of King Minos and to give form and historical reality to the Aegean Bronze Age. He called the culture of this ancient period after the fabled King Minos, and divided its years into the archetypal scheme of Early, Middle, and Late Minoan. He subdivided these chronological ages, tracing the slow growth and brilliant flowering of Minoan civilization until its collapse and destruction just prior to the last phase (Late Minoan III). Evans placed this "last sad period" in the history of the Palace of Minos at *ca.* 1400 to 1150 B.C. The broken shell of Knossos, as Evans depicted it, was occupied by poor, rude squatters, probably mainland Mycenaeans. To Evans, Mycenaean civilization was a late, provincial reflection of the once-magnificent Minoan.

We are indebted to Evans for what was to become, with a few minor altera-

tus, the canonical reconstruction of noan-Mycenaean — that is, Mediterrean — prehistory. With boundless energy, he also accomplished a partial toration of the island palace. But how es this Evans version of Minoan-Mycaean history tally with the picture at takes form after a study of the near B texts? The Pylos tablets coinle in date with the last phase (Late noan III) of the Palace at Knossos, d so it is this critical period that lmer examines. He finds Late Minoan to be a brilliant period in the history the palace, "when the Greeks were in ntrol," when a wealthy and sophistied society flourished, when many of e great works of Minoan art were proced, and when the tablets were inibed. Palmer then attempts to show ere, how, and why, in his opinion the an of Minoan archeology went wrong.

VANS placed the Linear B tablets that he found in the period *before* the l of Knossos, before its partial reocpation by "squatters." Hence, the fine and architecture contemporary with e tablets were, he said, products of the noan people who may have been under e political domination of the mainland ycenaeans. Palmer, on the other hand, lds that the Linear B tablets found at nossos are to be dated *after*, not before, e disaster of *ca.* 1400 B.C. That is, the blets and the splendid remains connporary with them were produced durg Evans' so-called Period of Partial occupation. It then follows that this riod must have marked a brilliant epide in the history of Knossos — with e island ruled by an enlightened Greek onarchy—not one of dismal decay.

To prove his thesis, Palmer must prove ans wrong. He sets out to do this. He mpares Evans' original field notes, ybook, and memoranda, written durg the course of excavations at the benning of this century, with the final blication of the *Palace of Minos* print- decades later. They do not agree, ports Palmer, on certain significant ints of fact. The original notes, which ust be considered authoritative, for ey were made on the spot as the dig ogressed, have convinced Palmer that e final published report is misleading d, in places, misstatement. Why do consistencies and error appear in the al report? Certainly not because vans set out to falsify the archeological cord in the several volumes that comrise his *Palace of Minos*. Rather, it is almer's feeling that in the intervening ecades, between excavation and publication, Evans had slowly built up his conception of Minoan history. By the time he sat down to write his extended report — he was then a man well advanced in years and decades removed from those thrilling days of discovery — his thesis had begun to dominate the evidence. As Palmer marshals the scraps of data, make his deductions from old notes stored away in the Ashmolean Museum archives in Oxford, and compares dates and handwriting, the reader begins to feel involved in a Sherlock Holmes adventure of scientific deduction.

Palmer's documentation is formidable, his logic is most persuasive, and his conclusions plausible. But the general reader of *Mycenaeans and Minoans*—and the book is written for both the general reader and the student of history—should know that Palmer does not hold the day unchallenged. Evans cannot answer for himself; he died over twenty years ago. Other reputable scholars of preclassical history, however, have contested Palmer's interpretations.

Palmer closes his book with a short chapter that can do no more than whet the appetite, for it deals with one of the most tantalizing and argumentative questions found in the historian's well-stocked storehouse of riddles: what are the sources of Greek culture? Palmer's approach is philological, backed up by the archeological. He takes us to Asia Minor, to that region in southern Turkey where in ancient times an Indo-European language called Luvian was spoken. He is convinced that this tongue is the basis of the still-undeciphered form of Minoan writing called Linear A. But a thin web of linguistic affinities is not in itself conclusive. Common customs, beliefs, social patterns, and modes of living must be established before two separate communities can be said to house the same people.

AT the Luvian center of Beycesultan (in modern Turkey) there are various striking Minoan affinities. Particularly important are what seem to be similarities between Luvian and Minoan religious furniture and cult objects. In the important area of architectural style and building techniques, the resemblances are too close and complex to be coincidental. Further, significant place names in Crete and Greece fall within the Luvian pattern. The evidence is slender, fragmentary, certainly inconclusive. But the picture that Palmer sees taking shape would show an Asiatic, Indo-European-speaking people established in Greece and Crete in "pre-Greek" times. This oriental cultural deposit would form part of the foundations upon which Greek civilization was built. Palmer does not pretend that his reconstruction represents historical fact. Rather, his hypothesis is in the realm of scientific probability based upon observable data.

DR. GOLDMAN, an instructor in the humanities, is with the Department of Art, College of Liberal Arts, at Wayne State University, in Detroit.

When does probability achieve the status of verifiable and absolute truth? In the field of prehistory, at least, the answer is probably never. The reconstruction of the past must be based upon facts, but the most important *facts* of the prehistorian's study are the dynamics of human activity, and these are irretrievable. The archeologist can only take the material result of complex human activity—a tomb, a shrine, a bit of pottery—and attempt to deduce from it the dynamics of the society. Hence, Palmer's Luvian episode can only be a "final assessment in this play of probabilities."

But recent news releases have again shown that the word "final" has no place in the prehistorian's vocabulary. Brandeis' Professor Cyrus Gordon announced recently that Minoan Linear A speaks a Semitic, not an Indo-European, language; that it is related to a Canaanite, not a Luvian, group. He estimates that those Semitic-language-speaking people, the Phoenicians — long known as intrepid merchants who sailed as far as the British Isles from their home ports on the Palestinian littoral — contributed more than alphabet to the Greeks; indeed, it is their Semitic-Asiatic culture that finds expression in the Linear A tablets. Luvian or Phoenician? This argument is no small matter of merely determining the language a lost people spoke. Rather, it poses the primary and profound question concerning the foundation on which Greek culture and its legatee, Western civilization, are built. Is it Indo-European coming to the West out of the Anatolian highlands of Turkey? Or is it Semitic, a Mediterranean offshoot of the ancient Near East?

As new archeological and linguistic data are recovered and can be brought to bear on the problem, revised assessments will be made by prehistorians, and Palmer will no doubt be in the vanguard. Asia Minor, in particular, must be watched in the next few decades, for the land holds rich archeological promise. It is there that Palmer's thesis will be tested. As current newspaper accounts relate, amazingly rich discoveries are being made there by Turkish, European, and American archeological expeditions. Undoubtedly they will supply much-needed light on these still somewhat mysterious Luvian language people.

But for now the casual traveler can catch the local bus that will carry him the few kilometers from the port town of Herakleion to the ancient ruins of Knossos, not quite asleep in the vibrant Aegean sun. Guarding the approach to the palace is a bronze portrait of Arthur Evans, the last "ruler" of the House of the Double-Ax, home of the Minotaur. Perhaps, as *Mycenaeans and Minoans* relates, Sir Arthur had feet of clay, but even King Minos was not faultless.

The Earth, The Temple, and The Gods, by Vincent Scully. *Yale University Press, $15.00; 257 pp., illus.*

Natural scientists and humanists have offered many formulas for documenting the uniqueness of man. For one scholar, man's distinctiveness lies in his solitary foreknowledge of his own mortality. Another notes that only man, of all animals, leaves behind products that arouse ideas beyond the facts of biological existence; while yet another humanist marks that man, and man alone, uses symbols. Greek sacred buildings are eloquent testimony of a people who were deeply involved in symbol making, in the production of an art that would long outlive them, and who knew the tragic lesson of life—which is death. Vincent Scully, of Yale University, takes the reader on an extended tour of the rugged landscape in which the Greeks placed their sacred buildings, monuments raised in the pious hope that they would bridge the chasm between mortal man and the undying gods. He attempts to reanimate them with their ancient symbolic meaning, to breathe into the shattered remains the pantheistic spirit that determined their shape and location. He writes fluidly and feelingly of ancient architecture within its landscape setting, imaginatively reconstructing, not the buildings, but the emotional and symbolic impact that Greek sacred places must have had on pilgrim or suppliant.

The basic thesis is that the Greeks did not arbitrarily erect buildings of some pre-established design with only practical and aesthetic considerations as the determinants of the architectural design and of the site selection. On the contrary, man-the-symbol-maker is the force with which we must reckon, for that is the loadstone to draw meaning into Greek architecture. The author is convinced that the Greek builder brought his temple design into a metaphysical harmony with a landscape that pulsed with symbols of the nature gods. Such temples, then, would not be based on inflexible design principles, but would adapt themselves in a variety of subtle ways to their symbolic roles. Landscape setting and religious associations in each case determined the architectural program.

Scully begins his pilgrimage of the holy symbols on the island of Crete, the home of the Bronze Age Minoan civilization, where he discovers that the axial orientation of palace architecture points to the neighboring hills that contain old shrines and legendary sacred places. It is the Great Mother of nature, the primordial concept of fertility embodied in the female, that the Cretans saw in these hills; toward the huge expressions of her body — the twin mountain peaks, the valley cleft between, the hill rising out of the valley — the Cretans turned

souls and their buildings. This retion of the Great Goddess in itain and valley becomes, for Scully, ll-pervading symbolic force carried Crete by the Mycenaeans of Greece to the mainland, where it is bethed to the Greeks of the classical The still-young Greeks introduced own male god who unites with, inates, but never quite replaces the t Goddess. And so Greek sacred itecture also turns to the sexual sym- of hills and clefts between for the ulation of its religious meaning. The or goes from temple to temple, ineting the intimate harmony that existed between sacred shrine and sacred landscape vessel.

many books on Greek architecture the subject in cold, analytical terms roportion, linear feet, engineering plexities, and so on, that a warm, essionistic discussion based upon d archeological documentation is welcome. Some readers, it is true, well ask if the tense, emotional ints of the book do not lie more in the he of the author than in the archiiral evidence. Or they may rebel at dramatic personifications of the inate, or feel quite unable to cope at s with the spate of emotional reises. The book is within the romantic ition of cultural history, and, as such, be judged prolix by those readers pollonian taste.

rofessor Scully makes it clear that study is not a primer of Greek itecture. It might be read with great it by the initiate, as well as by those have the basic facts of Greek civilin and architecture at their finger But this book is for the reader who not stumble over echinus, opisthod-s, hypaethral, and dipteral, for no sary is included. It is also for the ler who has stood upon the bleached ckage of those ancient sites and ed long at the tumbling hills of ece. The wealth of reproductions in book (including almost 350 photohs) attempts to convey the feeling he temples in their settings. But the lity of the photography falls far rt of that of the text. And the reader ld willingly sacrifice two-thirds of illustrations if the remainder could given full-page enlargement and ater contrast in the printing. The the author set himself was sureworthy of those heroic men who ed their magnificent temples against oding Mt. Parnassus. He has had to reate from landscape that has sufd 2,500 years of change, and from tered slivers of stone. Still, the Great ldess must have smiled upon him, for has taken to the task with obvious sh and stimulating results. He is to congratulated upon his ability to enand translate her ever-youthful favor.

IN BRIEF

High Dam Over Nubia, by Leslie Greener. *Viking Press, $6.00; 244 pp., illus.*

An enchanting, personal book has been written by Leslie Greener, who has been a member of the joint expedition of the Oriental Institute of the University of Chicago and the Swiss Institute of Cairo to Nubia. The expedition, as so many others these days, is concerned with the recording and salvage of archeological remains that are scheduled to be engulfed by the waters of the High Dam presently being constructed at Aswan in Upper Egypt.

Mr. Greener divides his book into two sections entitled "Today" and "Yesterday." The "Today" section describes the problems and some solutions occasioned by the construction of the dam. The description is written as a kind of travel tour, with Greener as guide through Upper Egypt and Nubia. The "Yesterday" section uses the Nubian monuments, one by one, to provide "windows" on the past, and the rich history of Egypt and the Sudan is thus revealed in vivid glimpses. The author is familiar with prime sources, both textual and archeological, and writes not only with authority but with a keen sense of the humanism of the past. His anecdotal style ranges through past and present and blends time into a singleness that many writers might well envy. It is good to find the facts allowed to speak for themselves without embellishments.

This is a fine book by any standard. It is also an important work for it emphasizes the truly monumental labors of archeologists involved in the Nubian salvage as they toil to save a priceless record of man's story for, unfortunately, a mankind that is very largely indifferent.

Walter A. Fairservis

The Patriot Chiefs, by Alvin M. Josephy, Jr. *The Viking Press, $6.00; 364 pp., illus.*

This book is good reading—objectively written and soundly based—although it arouses romantic and sentimental feelings for lost causes. We are now far enough removed from King Philip, Tecumseh, Osceola, and Crazy Horse to understand that they were great leaders and did not merely represent opposition to European conquest. This is a belated perspective but a responsible one. Mr. Josephy's account of the dramatic lives, and sometimes ignominious deaths, of the chiefs he has chosen to portray is also a statement of their ancient and varied social pattern—a way of life close to its natural environment, embodying great depth and great dignity.

John Hay

IN BRIEF

THE SEA, by Leonard Engel. *Time, Inc., $3.95; 190 pp., illus.* THE FOREST, by Peter Farb. *Time, Inc., $3.95; 192 pp., illus.* THE DESERT, by A. Starker Leopold. *Time, Inc., $3.95; 191 pp., illus.* THE MOUNTAINS, by Lorus J. and Margery Milne. *Time, Inc., $3.95; 192 pp.*

THE problem facing the editors of the "Life Nature Library" is the correlation of two mediums—book and picture magazine. *The Sea, The Forest, The Desert,* and *The Mountains,* four examples from *Life's* editors, are attractive, and in some ways provide good summaries of their material, but all suffer from the difficulty of juxtaposing pictures and text. The photographs are usually striking, in some instances, spectacular, but they have a way of making a barrier of themselves by standing in the path of explanation or simply changing the route suddenly so that the reader, now a viewer, finds himself in different country without a guide.

The Desert is characterized by eye-catching photographs, some of the best that money can buy. A. Starker Leopold has written a competent, interesting text and the book is full of up-to-date inf mation on one of the earth's most fas nating environments. The volume surely well worth owning and yet method, which is essentially encyc pedic, results in the presentation rather too much material for the limit space assigned to it.

The Mountains is an attempt to recti the fact that much of our knowled of mountains is of recent origin and h not been widely disseminated to the la man. This handsomely illustrated bo presents a brief but understandable r sumé of the geography of mountair the concepts of mountain evolution, t dynamics of volcanoes, the ecology mountain vegetation and animal life, tl unusual biology of mountain-dwellir peoples, and the adventurous story men and women (and dogs) who hav striven to conquer the highest, most i accessible mountain peaks known.

Because both the Milnes are profe sional biologists, it seems strange th the most serious errors in this volum —and there are a number—are to b found in the sections dealing with bi logy. The chapter, "Planets, Winds, an Ice," abounds with anthropomorphic an teleologic statements, as well as a v riety of factual errors. The book is wort its price. Not every statement it co

ains, however, should be accepted uncritically by the reader.

The Sea suffers by comparison with *The Forest*. The latter is written in a disciplined and competent style, while the former abounds in hasty generalizations and abrupt conclusions. As a result, more is learned of the forest than of the sea. Both books hold much (probably too much) to attract the eye, but the exactions of the picture and caption technique cut down on verbal expression. In future, the editors may be able to strike a better balance if they decide what sort of books they are producing.

THE OSAGES, by John Joseph Mathews. *Univ. of Oklahoma Press, $7.95; 826 pp.*

THIS book represents a noteworthy addition to the interpretation of Indian civilization, and although it contains over 800 pages, the length should not discourage anyone interested in the heritage of their native land—particularly when one considers that the author, John Joseph Mathews, is an Osage.

The Osages attempts to interpret and recount the cultural history of this Indian nation in terms of its own symbolism, ritual, and language, insofar as translation is possible. We are a long way from understanding the identification of a Neolithic people with natural forces. These people found their way by means of "the moss, the lichen, the stars, and the sun. . . ."

The symbolic culture of the Osages was far from "primitive" or "simple" as we are inclined to use those terms, but complex, precise, and beautiful in many ways. Because the author writes knowingly about the Osages, he accepts the authority of their religion and succeeds in making their decline and fall at the hands of the next "Americans" even more dramatic. The contrast between our two civilizations is sharply drawn, but the distinct impression remains that culturally the Osages were never totally crushed, and that their wild, ancient relation to the natural world remains relevant and unsullied. This is an exceptionally interesting and useful history.

NATURE ON THE RAMPAGE, by Ann and Myron Sutton. *J. B. Lippincott Co., $6.00; 328 pp.*

TO one who has always enjoyed nature's rambunctiousness, *Nature on the Rampage* is a disappointment. The rampages are listed by chapter headings but, unfortunately, they are not well chosen. For instance, chapters two, three, and four are titled "Winds," "Hurricanes," and "Tornadoes," respectively. "Rain," "Hail," and "Lightning" are the titles of three more chapters, and one gets confused as to whether the particularly heavy rains encountered in the last-mentioned chapter are associated with tornadoes, thunderstorms, or hurricanes.

"Deserts," too, seems a particularly inappropriate chapter title, for although the dry wastelands are cruel and most unfavorable to man, they hardly illustrate a rampageous nature but, rather, nature in one of its more stable attitudes.

The subject matter of the book should be of interest, but to the serious amateur in meteorology and geology, most of the material is "old hat"; and the scientific purist will be disturbed by the authors' sloppy use of the word "power," when it is "energy" that is being discussed.

Perhaps the plodding nature of the book lies in the self-conscious, almost forced pattern of the chapters. Each starts with a human interest story based on an actual experience, followed by a brief section of scientific explanation. And, as a finale, a bit of the mythology and history of the phenomenon is thrown in. One is left to wonder whether the two authors have any particular interest in any part of this repeated trilogy or whether it represents the publisher's idea for reaching a wide public.

a table, and open the front cover until it is vertical. This now makes an angle of 90° with the horizontal back cover. Close the cover halfway. The angle included between the covers is 45°. Now close the book half of the remaining angle. The angle becomes 22.5°, only 1° less than the angle between the planes of the equator and the ecliptic.

As the rotating earth revolves around the sun, it moves in the ecliptic plane and carries the equator plane with it. The earth moves in such a way that the equator plane always moves parallel to itself: the angle between the two planes remains unchanged and the direction of their line of intersection (the book's spine) constantly points in the same direction. (This is not strictly precise, but for our purposes we can ignore the small effect called precession of the equinoxes. The line of intersection will make one complete turn around the ecliptic in a period of nearly 26,000 years.)

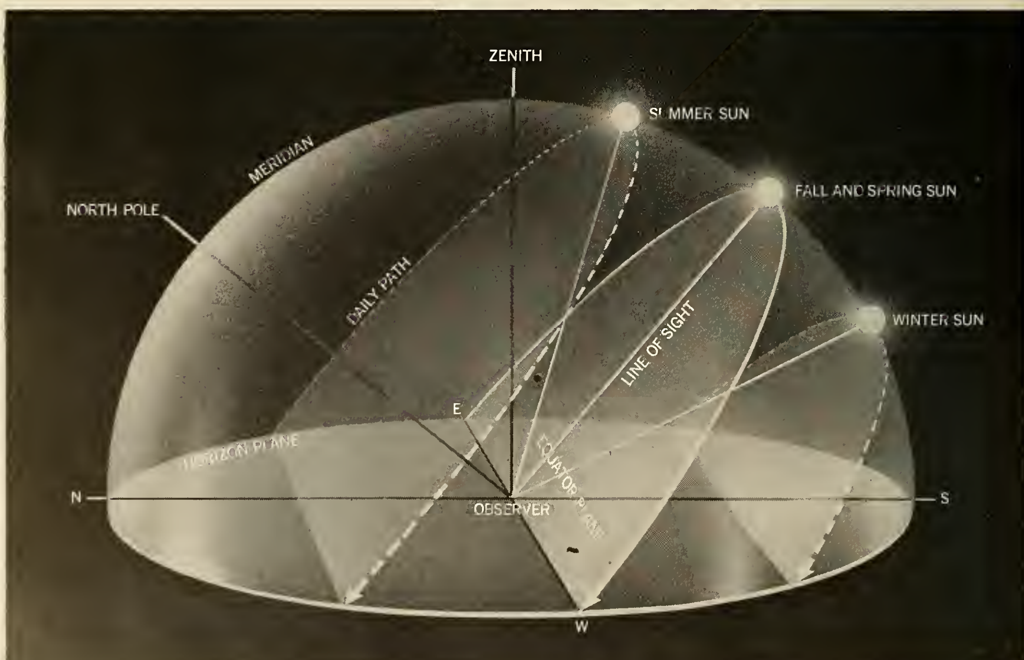
We live on the surface of the earth, which rotates on its axis 365 times faster than it revolves around the sun. We give greater importance to the day as a unit of time and to celestial positions based on the equator, although we are fully aware of changes in the sky during a year's time. During the winter in the Northern Hemisphere the sun appears low in the sky, because the equator plane extends to the north of the sun. Six months later, the opposite part of the equator plane extends to the south of the sun, and the sun appears north of the celestial equator. At a certain time between these two extremes, the line of intersection of the planes will pass through the sun so that the sun appears to be on the equator. Our nights and days are then equal in length, hence the word equinox is applied to both times. If you place a small lamp on the table and reopen the book, you can duplicate this effect of the seasons by moving the book, keeping the partly open front cover parallel to itself as the book is moved around the lamp.

Dr. Franklin, whose work appears regularly in the pages of Natural History, is Associate Astronomer on the staff of The American Museum — Hayden Planetarium.

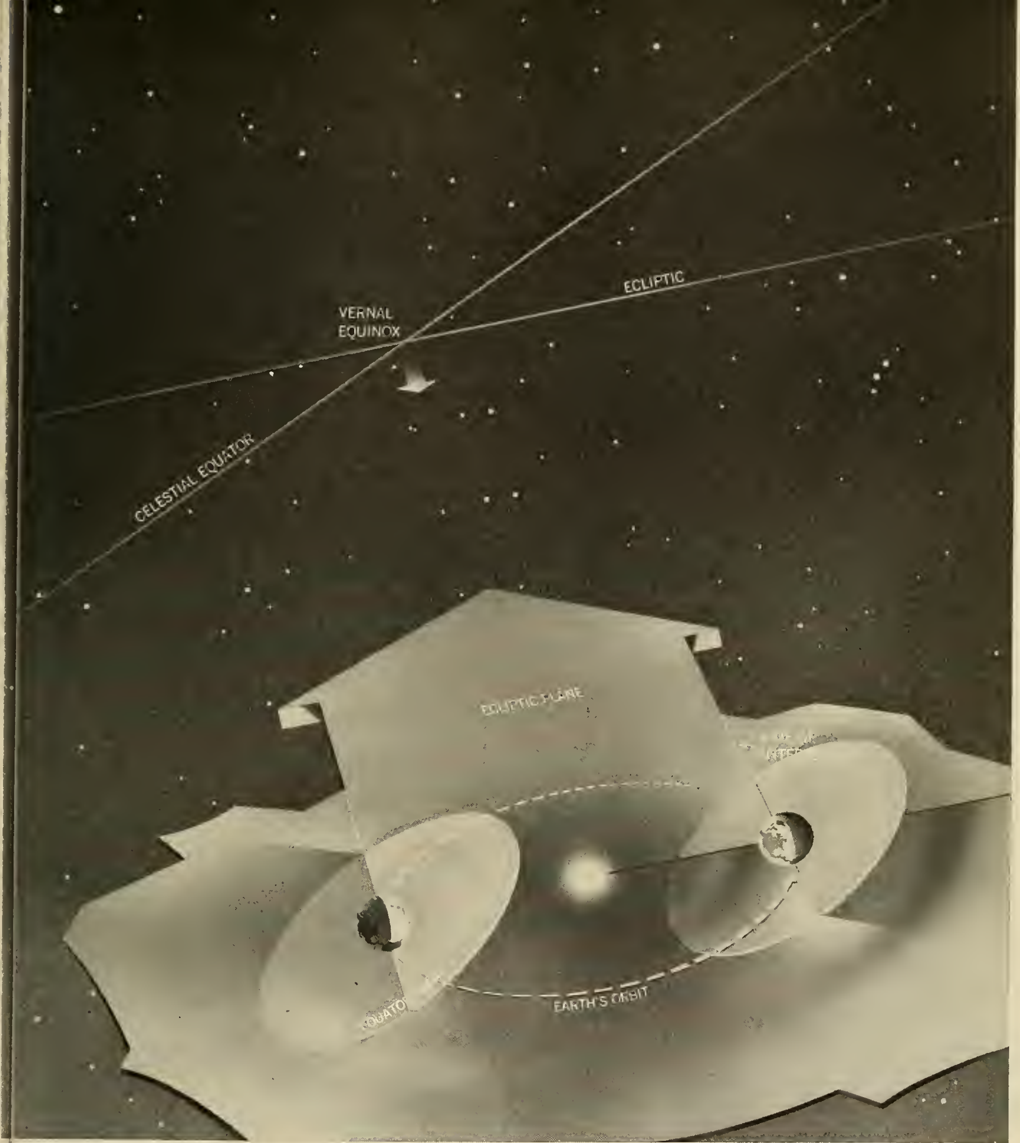
This inclination of the equator plane to the ecliptic plane of the earth explains the apparent north-south motion of the sun in the sky during a year. It also leads us to the following partial explanation of the variable time-keeping properties of the sun.

For all but extremely precise work, observatories use the rotation of the earth as the basis of time-keeping. Astronomers who determine time use the stars as reference marks, noting when they are on the celestial meridian. A star exactly on the equator will take 24 sidereal hours between two successive appearances on the celestial meridian. This is exactly the same length of time taken by any star anywhere in the sky to return to the meridian; therefore, a star's or the sun's distance north or south of the equator will not affect time-keeping.

Since the sun apparently moves around the sky (reflecting the earth's revolution around the sun), the sun will not line up with any star for longer than an instant. If we could observe the sun and a star on the meridian on one day, we would find on the next day that the star — which is fixed on the celestial sphere — would appear on the meridian about four minutes



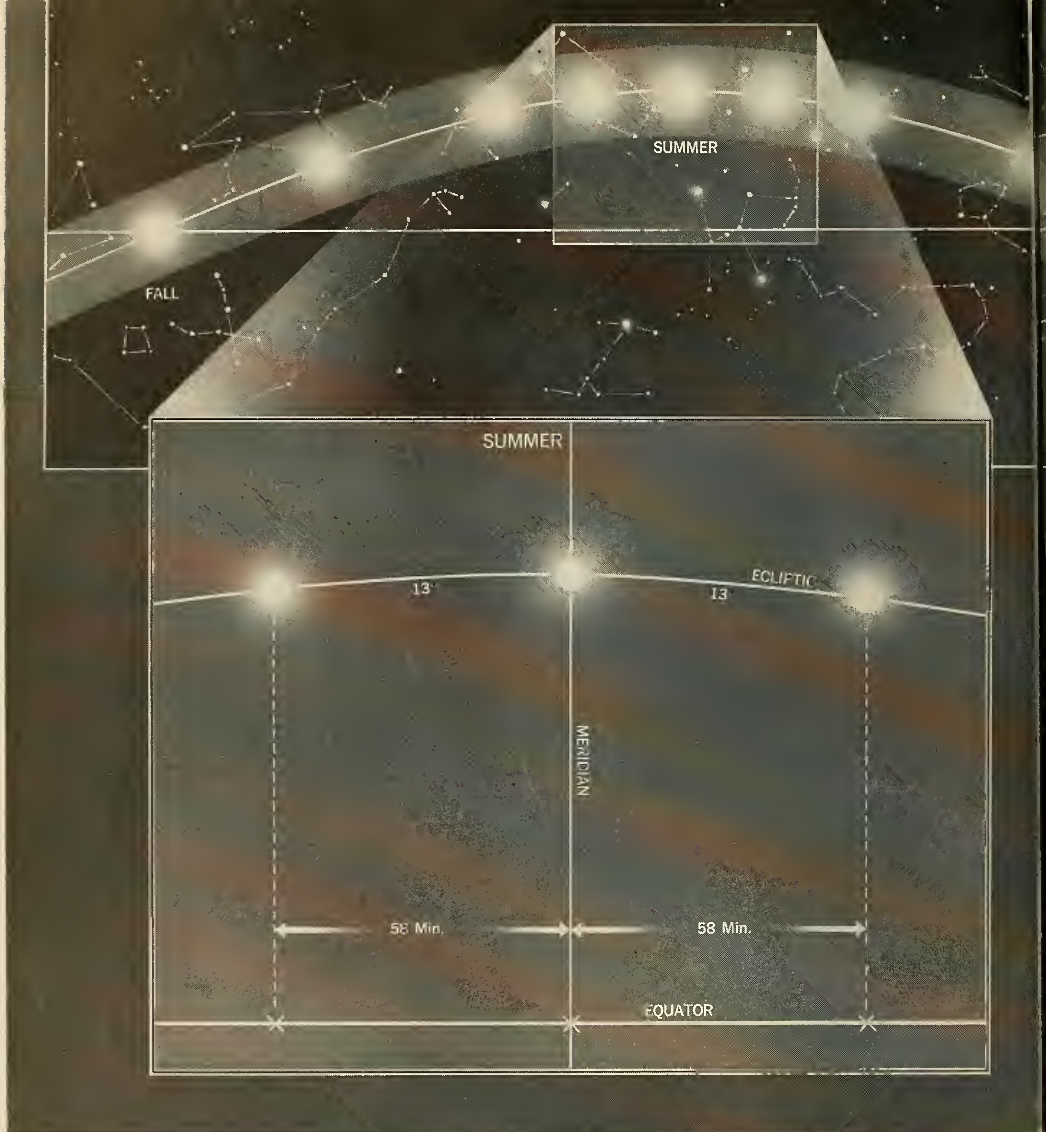
Change in altitude of sun on the meridian with respect to the celestial equator is demonstrated in the illustration, *above*. Paths traced by sun on celestial sphere are given for the opening days of spring, summer, fall, and winter.



E:TH'S EQUATOR PLANE stays parallel to itself as the earth r olves around sun. Angle between equator plane and the ecliptic plane is constant. When the line of intersection passes through sun, day and night on earth are same length.

s ner than the sun. This difference a ls up to about two hours in a month. B :ause man regulates his affairs by t sun rather than by the stars, he is c icerned with solar rather than si- d eal time. Sidereal hours are slightly s rter than solar hours, so it is im- p tant, in time calculations, to specify t kind of time units that are used. n December and January the sun is a parently moving eastward at such a r e that the earth must turn more than four sidereal minutes longer each day to bring the sun to the meridian. The same is true in June and July. Between these seasonal extremes, the sun seems to be moving northward or southward in the sky, with the greatest motion in March and September. An appreciable fraction of its total motion along the ecliptic is "wasted" in this north and south movement, at least in relation to determining time. Thus, for time-keeping, the sun's effective location on the equator is changed more slowly during spring and fall. At these seasons, the earth does not have to turn so far (about 3.6 sidereal minutes past 24 sidereal hours) to return the sun to the meridian each day.

THE analemma would be a symmetrical figure 8 with respect to the meridian and the equator if the inclination of the axis were the only cause operating. The motion of the

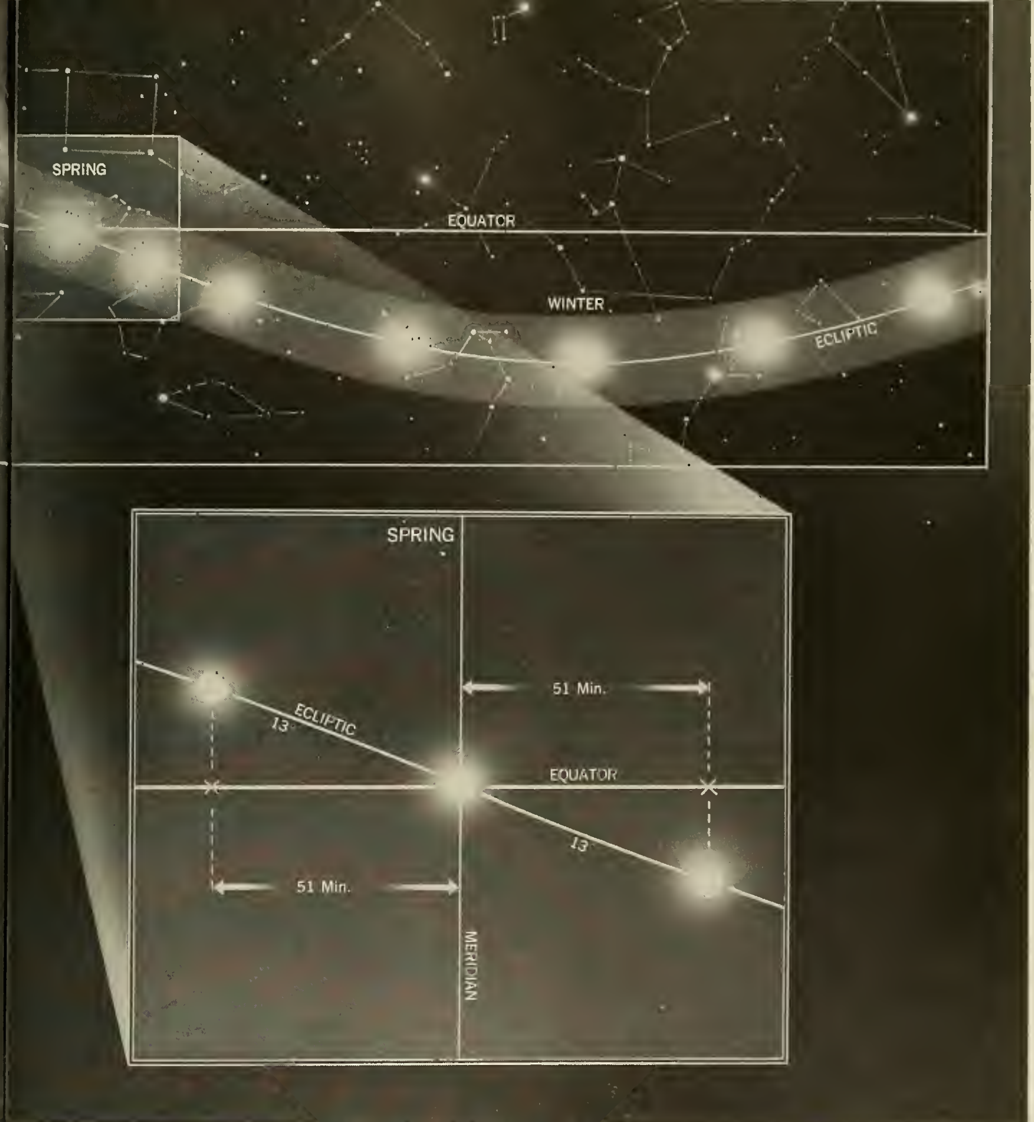


Sun moves slightly more than thirteen degrees along the ecliptic during every two-week period. In the summer and winter this motion is nearly parallel to the equator; in the spring and fall less of the thirteen-degree movement

sun along the ecliptic is not uniform, however, being faster in winter and slower in summer. This effect was known to ancient astronomers, but was first described mathematically by a simple law that was deduced by Johannes Kepler.

Kepler was a mathematician who became an assistant to Tycho Brahe, at that time the world's best astronomical observer, about A.D. 1600. Tycho had accumulated accurate observations of the planets for many years. Kepler used the positions of the planets to determine certain laws that described the motions of the planets around the sun. One law stated that each planet moved in an elliptical, rather than a circular, path. The sun was located at one of the focal points of each ellipse. A second law concerned the speeding-up of each planet as it passed perihelion (the point in its orbit when it is closest to the sun) and its leisurely passage of aphelion (the point farthest from the sun).

Consider again the line between the earth and the sun that generates the plane of the orbit. The line covers a certain area of the orbit from week to week, completing the orbit in a year. Kepler discovered that the area the line generates is exactly the same size every week of the year: the line joining the planet and the sun sweeps

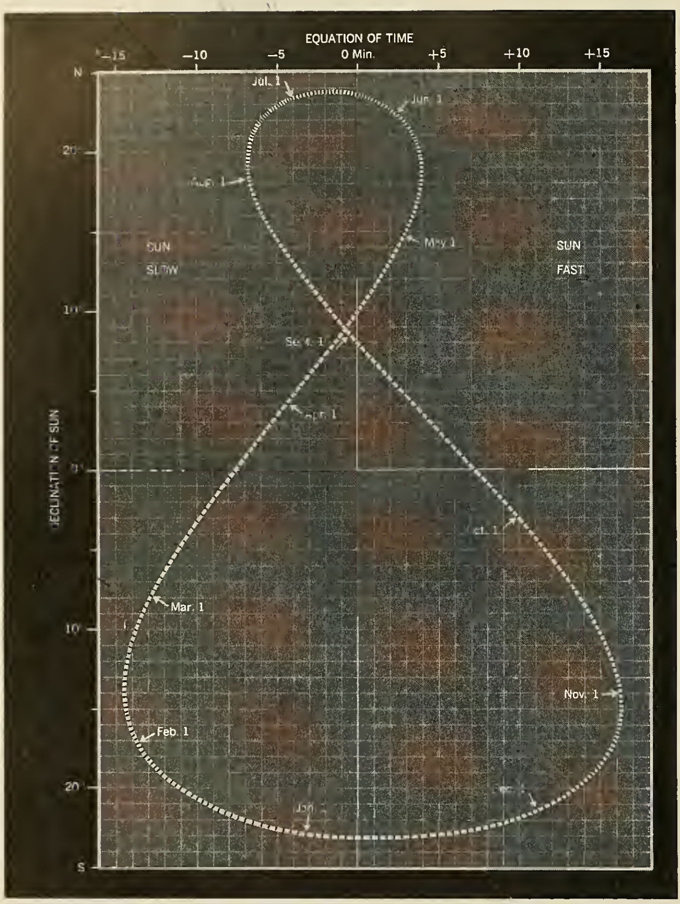


is transferred to equator for time-keeping purposes. The daily intervals from a sundial noon to a sundial noon are longer in summer and winter than in spring and fall. This variation is the main cause of the shape of the analemma.

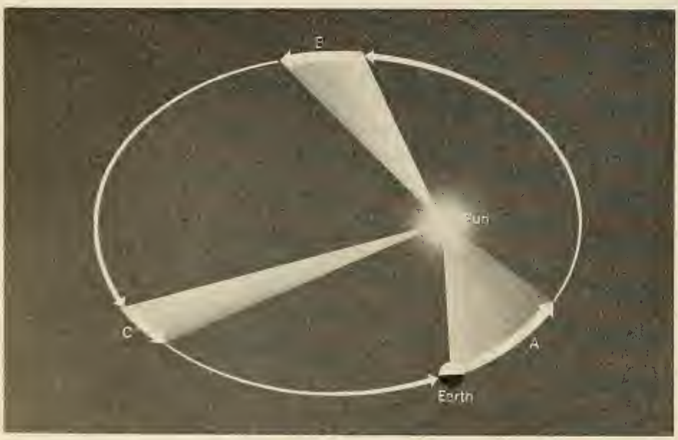
over equal areas in equal times. When the earth is close to the sun, the line is short; so the earth must move fast to cover the required area. Around aphelion, the line is long, so the earth may move slower to describe an equal area.

Since our motion around the sun makes the sun appear to move around the sky, our varying speed is reflected in a variation of the speed of the sun along the ecliptic. The earth is closest to the sun about January 2, so the sun moves farther along the ecliptic in a day at that time than it does in other parts of the year. The rate of the earth's spin does not change, however, so the earth must turn farther each day to bring the sun back to the meridian. During the summer the sun moves slowly along the ecliptic, so the additional turning is less than in winter.

There are, then, two independent effects that combine to produce the analemma. One is the eccentricity of the earth's orbit, which causes a change in the apparent speed of the sun across the sky; this change goes through a complete cycle in a year. The other effect is caused by the inclination of the equatorial plane to the ecliptic; this causes the sun to move obliquely with respect to the equator, resulting in a speed across the sky that goes through two cycles of change in a year. The second effect is larger, so it predominates in producing the figure 8.



Lissajous figure results when daily differences between sundial noon and clock noon are plotted in relation to the sun's declination during one year.



Kepler's second law is demonstrated, *above.* Earth traverses orbit segments A, B, and C, of differing lengths, in identical time. Light areas are equal.

Since the sun takes varying length of time to return to the meridian eac day, the sun cannot be used as a goo time-indicator. It would be much mor convenient if we could replace the tru sun with a fictitious sun — one tha moved uniformly along the equator The fictitious sun could be matche to the real sun at the beginning of eac year, and its motion could be timed t coincide with the true sun at the en of the year. In effect, the fictitious su would smooth out the variations o the true sun and be a regular time keeper, having the average motions o the true sun. Astronomers have actu ally used the concept of an averag sun for centuries. The time determine by the mean sun is mean solar time and is the basis of our standard time

As the man with the sundial dis covered, clock time can diffe from sundial time. The latter is calle apparent solar time, because it is de termined by the place where the tru sun appears to be in the sky. If differ ences between the two methods o keeping time were correlated, the tabl of differences, taken in the sense o apparent time *minus* mean time, woul be called the equation of time. A diagram of the analemma can be pro duced if the equation of time is plotte horizontally and the declination of th sun (position north or south of th equator) is plotted vertically (see th illustration at upper left).

It is only after these prelimin aries that we are able to define the analemma simply. It is a one-year graph of the sun's declination and the equation of time. The shape of the analemma is produced by the inclination of the earth's axis and the eccentricity of the earth's orbit.

Distortions and asymmetries in the analemma's form are chiefly a result of differences in the starting time of the two effects. If the earth could be at perihelion and at the winter solstice at the same time, the analemma would be symmetrical around the meridian. There is no physical reason why these two dates should coincide, so it is only by chance that they are about eleven days apart at this time. Disturbances in the motions of the earth, caused by the presence of the other bodies in the solar system, result in this difference changing over the years.

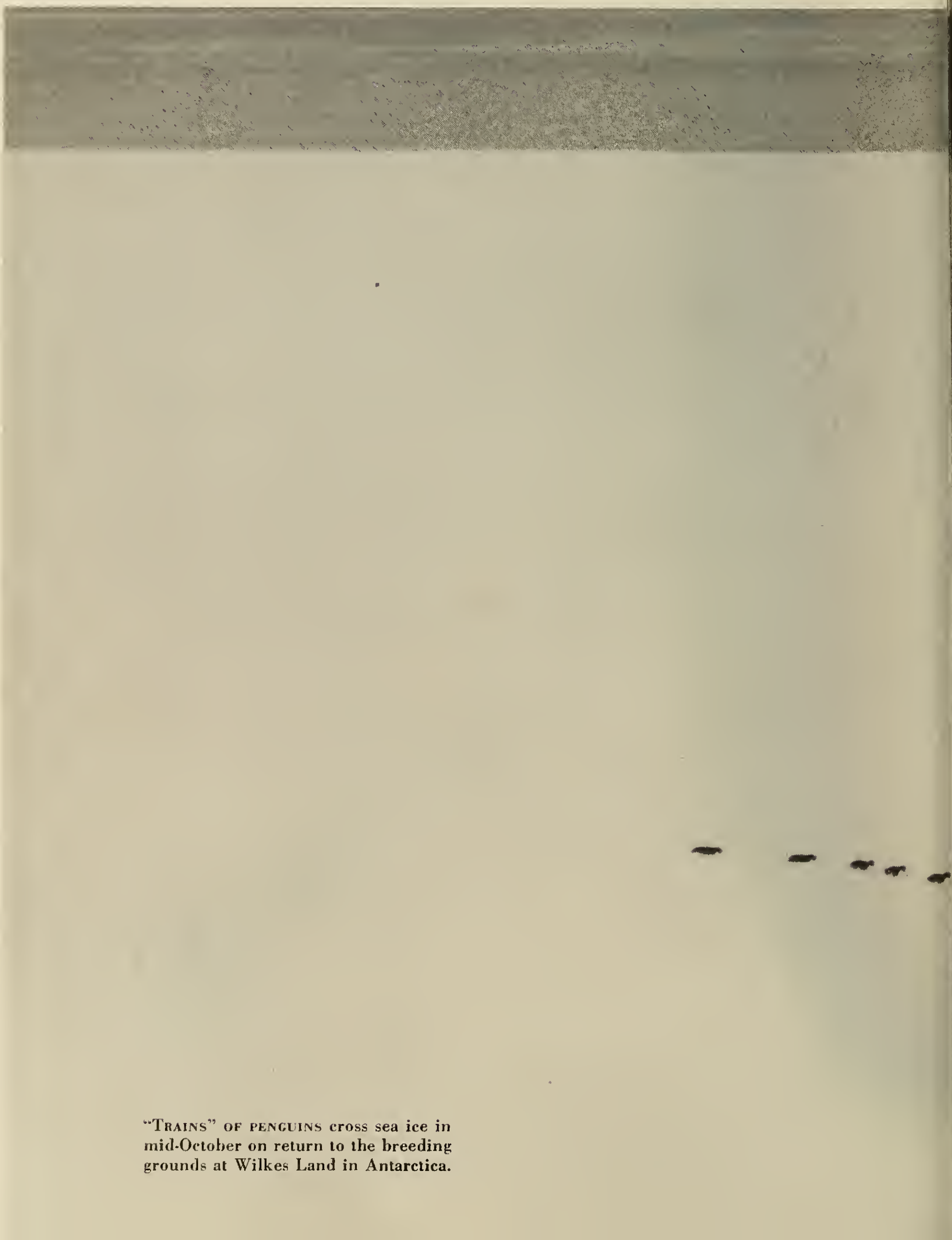
Sun's shadows at clock noon during year trace analemma's shape on ground.


SUN'S SUMMER PATH
June 15
July 26
May 14
April 16
September 1
CELESTIAL EQUATOR
March 21
September 23
MERIDIAN
February 11
November 3
SUN'S WINTER PATH
December 26

Breeding behavior is influenced by vocal recognition

Voices of the Adélie

By Richard L. Penney

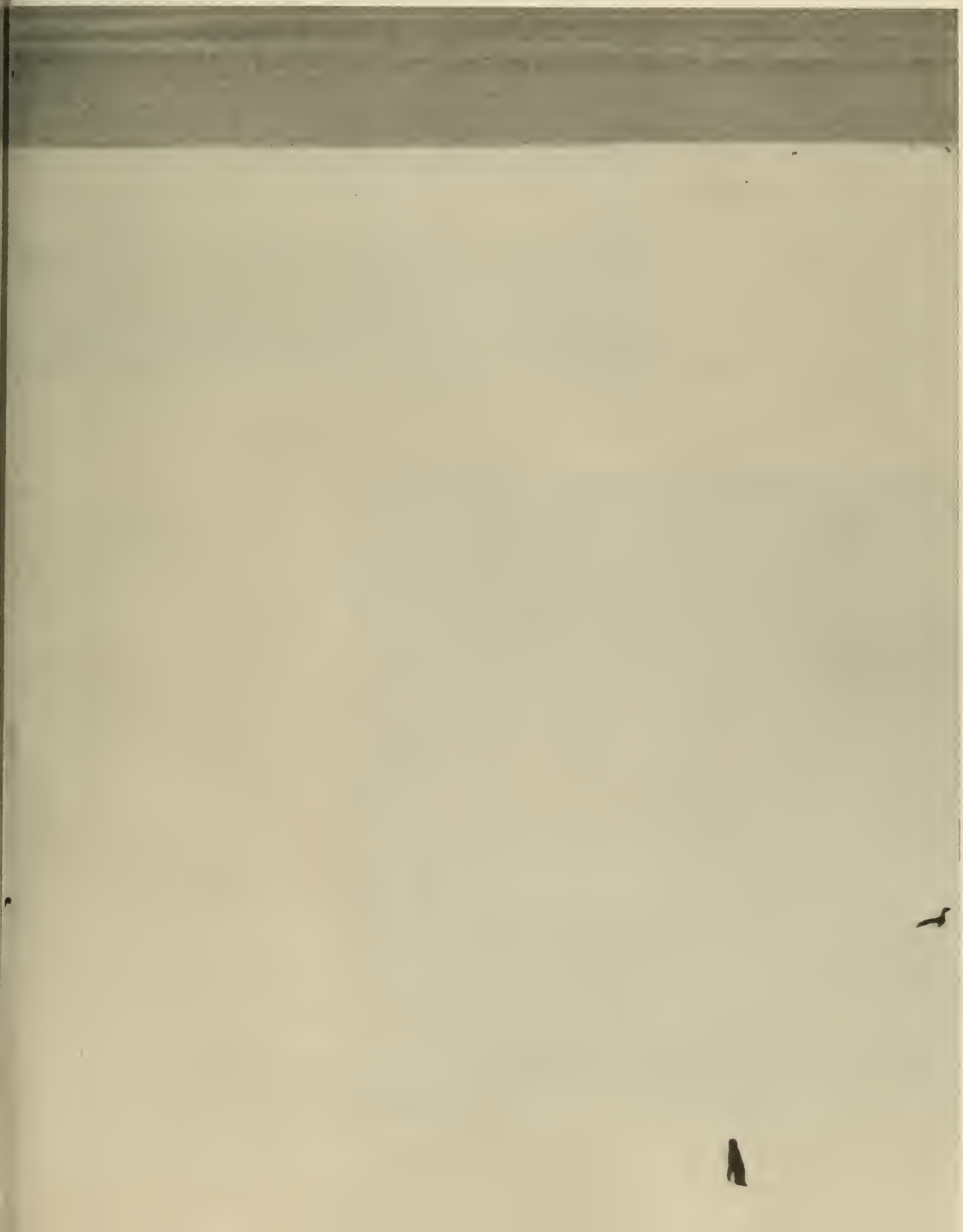


"Trains" of penguins cross sea ice in mid-October on return to the breeding grounds at Wilkes Land in Antarctica.

THE SOUTH POLAR PENGUINS are members of the taxonomic family pheniscidae, in which there are sev-nteen species that range from the ropical islands of Galápagos down o within 800 miles of the South Pole.

There are only two truly Antarctic pecies—the largest of the family, the mperor *(Aptenodytes foresteri)*, and the medium-sized Adélie *(Pygoscelis adeliae)*. The latter in particular have attracted explorers' attention for the past 75 years, and around their curious habits and odd appearance have been woven many a tall tale.

The observations of Dr. Edward Wilson and Dr. G. Murray Levick on British Antarctic expeditions during the early 1900's gave us a general view of the Adélie penguin. They first saw the Adélies standing on ice floes as the ships fought their way south through the pack ice. Once inside the pack, in the open water between the pack and the continent, the men again observed large numbers of penguins, this time propelling their curious little bodies

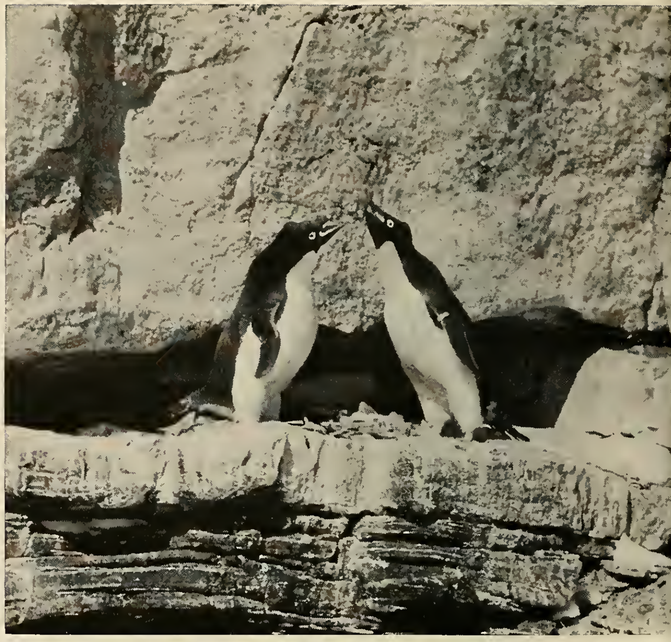


through the water at the speed of the ship. Upon reaching their destination, the explorers found that the Adélies had beaten them to the choice camping sites—the exposed rock of the Antarctic coast—which is inhabited during the summer months by vast rookeries of the birds. It is here that they build their nests of small stones, lay their two eggs, raise their young, and then depart again for the pack ice to the north, where they spend the seven winter months feeding on krill—small, shrimplike animals, primarily members of the genus *Euphausia*.

Two questions occurred to the early observers. First, how could so densely concentrated a group of birds order their lives and successfully raise their young under such stringent conditions of wind and cold? Second, as each bird, whether male or female, appeared to the human observer exactly like the next, how could a returning mate find its partner, the correct nest, or its chicks?

In 1914-15, Dr. Louis Gain began to answer some of these questions by marking a group of adult birds with colored leg bands. A year later he found several breeding in the same area where they had been banded. Unfortunately, this very obvious technique of marking birds and following their activities was not attempted on a large scale with the Adélie penguin until the late 1940's, when Dr. W.J.L. Sladen spent two years in the Falkland Islands Dependency Survey—one at Hope Bay and another at Signy Island. Simultaneously, the French biologist Dr. Jean Sapin-Jaloustre and his co-workers were carrying out an ecological study on the Adélie penguins in Adélie Land. Sladen marked his birds with aluminum bands and observed them throughout the breeding season. Many of his conclusions formed a starting point for my own study, which was carried out from 1958 to 1961.

Under the sponsorship of the National Science Foundation and the U.S. Antarctic Research Program, I spent twenty-six continuous months in the Antarctic, where I established quarters among a small rookery of 3,000 breeding birds. The procedure was to band and closely observe a large number of breeding adults, chicks, and one-year-old juveniles



LOUD MUTUAL DISPLAY takes place as pair that mated the previous year meet at nest for the first time after having been separated for seven-month period.

OCCUPATION OF TERRITORY is begun as male gathers stones for nest and seeks its mate. Later, female aids male in stone-gathering and hollowing out pile.

ECSTATIC DISPLAYS by males on nests are characterized by bowing and by a head-up stance, accompanied by throat rattling and slow beating of flippers.

a loss and gain in birds throughout the study period. By observing these marked birds throughout the 1959-60 season and again during the 1960-61 season, it was possible to construct a résumé of their breeding behavior.

The first individual at the breeding grounds in spring arrives in the middle of October, followed by large numbers of its fellows that come in over the sea ice a few days later, appearing at first as little black dots visible at a great distance on the white expanse of ice. They may come either singly or in groups. When in groups they are in "trains," weaving along over the sea ice and the snow. This much-advertised and odd behavior pattern, in which one bird is followed by several in a row, all pushing themselves along on their bellies, is especially obvious when the snow is soft and deep. The preference for a "broken" trail is demonstrated in this behavior, for if I dragged my feet through the soft snow, groups would follow me about in all sorts of strange configurations not leading to the rookery. This following is further stimulated by the attraction

throughout two consecutive breeding seasons—something that had not been done previously, but was essential for answering many questions concerning nest site stability, faithfulness to mate, and breeding age. In this article, the information will be drawn primarily from the behavior observed in one of the thirteen colonies under study. The behavior of these birds is typical of that found in over 1,000 other banded birds, because each colony of the rookery functions as a population unit and there is very little intercourse between the separate colonies.

IN colony IV, I banded every adult and located its nest by map or marker during the 1959-60 breeding season. This included not only the breeding birds but also those that took up temporary residence, such as a male claiming a nesting territory late in the season or a female stopping by temporarily to "keep company" with such males. Seventy-six individuals—36 females and 40 males distributed in 37 nesting territories—were banded under such conditions. The excess of males for each site is due to intermittent occupation of the same site by more than one "wandering" bird or

FLOODING OF NESTS is not infrequent occurrence, and here male attempts to rescue egg by building new nest around it. Watching female seems unconcerned.

that almost any dark-colored, moving object apparently has for them.

These unique trains have suggested to some that it is a way for "unknowing" birds to be led back to the breeding grounds. This, however, does not appear to be the case, for the leadership often changes throughout many miles of travel, and when the sea ice is fresh and hard, such trains tend to be considerably reduced.

Once the gregarious birds enter the rookery, there is a distinct change in their behavior. They are now no longer so responsive to the movements of the other birds, and each goes his or her own way in a specific manner. Generally the males return first. Twenty-eight pairs came back to colony IV in the 1960-61 season. Of these, fourteen pairs had the same mates and returned to the same nests as in the previous year, with eleven of the males preceding the females back to the nesting territory. Having immediately taken up the previous year's territory, the male protects the area from all intruding males, if necessary fighting a long, hard, and sometimes bloody battle with bill and flippers. Occupation of the nesting territory involves—in addition to defense—gathering stones for the nest and a spectacular, intermittent ecstatic display. Rearing his head up and back, the male waves his flippers slowly back and forth while emitting a low, pulsating sound. The climax is reached with an ear-splitting and reverberating "gaa,aah,aah,aah."

THE sound attracts a female and she approaches the territory of the male. Should she be a stranger, she approaches the nest with an appeasing bow of the head and with stares from one or both eyes. If staring with one eye, the side of the head faces the male; if with both eyes, the bill faces him, and the stare is somewhat cross-eyed. As the display ends, the male replies to the female with similar staring and with a bow that is often over his shoulder. This is followed by a remarkable performance in which the male lies prone on the site and, using his feet, begins scraping a hollow in the pile of stones he has collected. A routine of stone-gathering and intermittent loud and soft mutual display-

INCUBATING OF EGGS is done by males while females feed. Distance between the nests averages twenty-eight inches.

ng then begins unless the pairing is plit by the return of the male's mate f the previous year. When this hap- ens, the newly returned mate will early always fight with or at least lrive off the first female. The second emale then joins her mate amidst loud nutual displaying and vocalizing.

The loud and the soft displays are listinct phenomena, not simply grada- ions of sound. During both types of lisplay, the heads weave back and orth. In the soft type, the bills are ept closed, while in the loud, the bills re open and the resulting sounds can e heard a mile away. This display is, s we will see, a means of confirming dentification. Should the male not be resent when the female returns she vill often wait about the colony for a lay or two and then will take up with "single" male. In this way, new pairs re formed from both old and newly reeding birds alike.

IT is unusual for a returning female or male not to reunite successfully vith its former mate, except in the case f very late return. The birds demon- trated an amazing capability for head- ng directly for a precise nest when eleased on the polar plateau some 35 niles inland and well out of sight of he rookery and the sea. In another ase, on December 3, 1959, I sent five dult males on a plane to McMurdo Sound, where they were released. The next October, three out of the five were ound back at their previous nests, aving walked and swum for over 2,400 miles along the coastline. This s a good pace of about eight miles laily, as they do not travel at night, and winter days are very short. In ad- lition, of course, it was necessary for hem to stop to feed on the way.

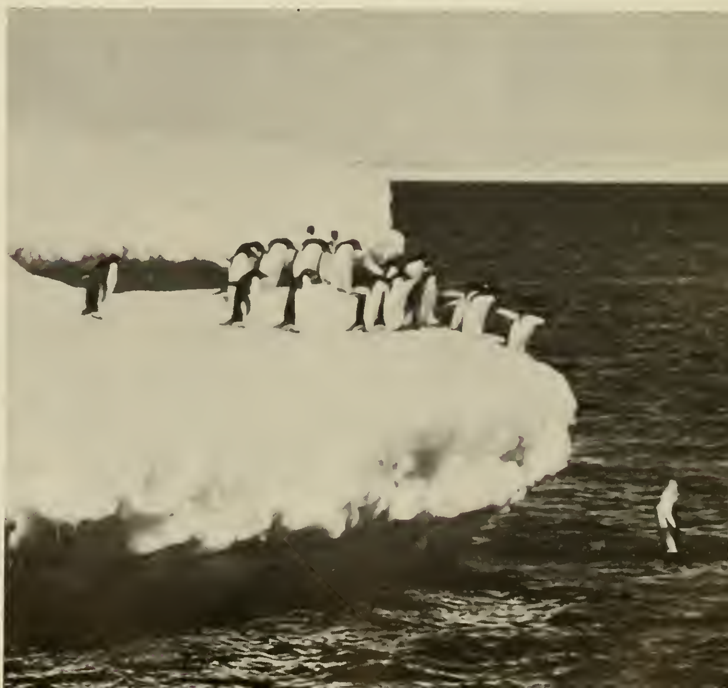
Both sexes share in the stone-gather- ng and the scraping of the "scoop" or hollow in the stone pile (sex cannot be established by following the com- non misconception that males present stones to females). Coition occurs very soon after the pairs are formed and is repeated many times until the eggs are laid and even between the first and second egg. Egg-laying begins in the middle of November, when nearly all the birds are in the rook- ery. Two eggs are laid two or three days apart, after which the female leaves for the sea to break her fast of usually two weeks. The male stays be- hind to incubate the eggs. Often, re- versals in the routine of incubation occur in some special circumstances.

MALES, relieved from nest duty upon return of females, gather in groups on edge of ice before breaking long fast, which may have lasted for forty days.

The female returns after a couple of weeks. She pops out of the water onto the ice foot at the beach along with a group and heads directly and rapidly for her mate and nest. Upon nearing and reaching the site and mate, there is an instantaneous loud mutual display. A short "nest-relief" ceremony ensues, in which the female takes over the incubation and the male gathers a few stones to replace those stolen by late nest builders. He is then free to depart and break his fast, which may have lasted forty days. The departing birds gather in groups on the edge of the ice, leaving abrupt- ly when sufficiently interstimulated. First they clean and preen themselves in the water, and then, at a steady pace of 8 to 10 miles an hour. they head out toward the pack ice and food, where they stay for about two weeks.

One of the more interesting facets of my research concerned individual recognition between mated adults. The question of inter-mate recognition from one breeding season to the next

ABRUPT DEPARTURE occurs when enough interstimulation has taken place. The birds then jump from the edge of the ice to water six or seven feet below.



ALUMINUM BAND is attached to bird's flipper to facilitate checking of the re-formation of pairs and their return to former nest sites in the next season.

is pertinent when considering whether it is faithfulness to territory or individual recognition that keeps pairs together from year to year.

WATCHING many re-formations of banded pairs early in the season, observing closely the fights between females over males (a male fights for his nesting territory and its female occupant, not the female per se), and recording the events of many nest-relief ceremonies, I was impressed by the predominance of the very loud mutual display. As was also concluded by Sladen, the display's vocal aspects seemed to confirm the identity of individuals. This idea was thoroughly supported by natural experiments or "mistakes" by a returning bird. On several occasions, banded birds were observed to rush up to the wrong nest and give the loud call of the nest-relief ceremony. Instead of getting the usual reply, they were pecked by the incubating or guarding bird on that nest. I observed that if the mistaken nest and mate were adjacent to the correct one, the proper mate would answer loudly, and in response, the returning mate would move to the correct nest.

AFTER HATCHING, young are covered by one or the other of the parents for four or five weeks. During this time their weight increases enormously, and when they are about two weeks old the bodies protrude from under covering parent.

While trying to think of an experi- iental setup to test such recognition, discovered that some broody incuba- ing adjacent males or females could e switched to each other's nests. I iade five such switches and recorded he results for banded pairs. It was ound that the returning mate would t first return to the correct nest. call oudly. get pecked, and then join the orrect mate (on the wrong nest), vhich had replied to the initial call, bviously having recognized the voice. n each case, the breeding routine re- iained normal and the eggs of the ther nest were raised. From this I onclude that in both sexes the recog- ition of mate overrides preference for he nesting site, and that audition is a iore essential cue in establishing dentity than is vision.

The eggs hatch after an average in- ubation period of thirty-four days. Aeanwhile, the nest reliefs have be- ome more frequent until they are only hree to four days apart at hatching ime. The young chicks are fully cov- red by the parent on guard (the next our or five weeks are called the guard tage) and fed on regurgitated krill vell mixed with digestive fluids.

Mr. Penney is now between research trips to Antarctica. He is presently Research Assistant in University of Wisconsin's Department of Zoology.

The seemingly insatiable appetite of these chicks soon transforms 80 grams of fuzzy down into rotund and very comic creatures. When two weeks old, it is already difficult for the parent to cover them, and their well-insulated bodies are to be seen protruding from under the parent. When four weeks of age. the nest-relief ceremonies are down to about one day apart, and a chick that weighs about 1,500 grams can easily hold that weight in food.

At about five weeks, the chicks are deserted by both parents. which are busy gathering food and return only briefly to feed the chicks. It is now the second or third week of January. and the deserted chicks gather in groups called crèches. Often there are some adults present in the colonies with the crèche. It was formerly thought that these adults were left behind to act as "guardians" of the crèche to protect them from their ever-present enemy—the south polar skua *(Catharacta skua maccormikkii)*, scavenger-predator of similar distribution to that of the Adélie. However, as stated by Sladen, the guardians are not guards at all, but are merely unsuccessful breeding birds that have returned to the rookery to claim or maintain a claim on a nesting territory. In actual fact, I feel some such protection does occur. A reoccupying adult Adélie protects a considerable area around the "claim" as compared with an adult early in the breeding season. This defense even extends to the crèche chicks. although they are treated with a certain ambivalence. Should a skua land near a colony or, especially, near the claim of such an adult, the Adélie will charge. The skua usually flies away, so the Adélie's action functions in a non-purposive way as protection of the chicks.

In the absence of adults, the chicks huddle together in the colony until a parent returns with food. The parent bird enters the colony, finds the previous nesting territory (the nest itself is now obliterated), and gives the familiar components of the loud mutual display to the ground. The chicks hear the voice, come running, and are fed. On occasion, these chicks are 30 to

Voice recognition by young is demonstrated when both of the parents are gathering krill and chicks are huddled in crèches. When parent returns with food to obliterated nest site and calls, only its own chicks respond to its voice.

Molting adults seek protection from wind on lee side of hills, where they gather in small groups. During molting they lose half of initial body weight.

40 feet from the location of the former nest. Only the adults' own chicks are fed, even though several may give chase and beg for food. This was first demonstrated by Sladen (working with marked adults and chicks), who finally disproved the old idea that the healthiest and the strongest chicks were the ones fed during feeding chases.

This parent-chick recognition was of special interest to me. For the first few weeks of the chick's life outside the egg it has many opportunities to hear and learn the voices of the two parents during the nest reliefs of the guard stage. It seemed logical to me that auditory recognition could be functional during the crèche stage, and to test it a loud-speaker was set up outside the colony when all adults were absent. The crèche of chicks was sleeping in the center of the colony. When a previously recorded portion of a particular parent's loud mutual display was played back on the tape recorder and over the loud-speaker, it was found that the marked chicks of that particular parent got up from the crèche, looked about, and then hurried over to the original nest site to remain with what can only be described as an "anticipatory air." This experiment was repeated ten times, using various recordings and marked chicks, and nine times the results were positive. Significantly, none of the other chicks reacted in this manner, but remained huddled in the crèche, a few of them merely looking up.

The crèche stage of the breeding season continues into the second week of February while the chicks molt their down and come into their juvenile plumage. During the molt one year later, they will attain the plumage of the black-throated adults. The crèches begin to break up as the plumage of the juveniles develop, and most of the feeding chases end on the beach. Here the chicks remain moving back and forth in groups along the now ice-free beach of bedrock. They get "excited" by the sight of swimming birds, and rush around exercising their flippers with a very rapid whirring, while calling in a distinctively immature "aark." Soon they enter the water and navigate quite independently of the adults, although their aquatic habits are comically those of novices. Finally they head for the pack ice to the north, where they will remain until they reach breeding age.

The breeding grounds now become very quiet, even though there remain several hundred adults and a few juveniles that have returned or remained in the rookery to complete thei change of plumage. At this period have engaged in a penguin roundu with the help of some Australians fron the main base. I have "herded" ove 100 pugnacious and stubborn moltin penguins into a corral so I could ban and weigh them. What starts out as calm and well-organized drive ends u in near chaos and considerable "lan guage" from both men and birds.

The molt period begins with th bird at its maximum weight for th entire year and lasts for an average o twenty-one days for adults. Nearl 50 per cent of the initial body weigh is lost during this period. The bird remain in small groups on the lee sid of the hills out of the fierce winds tha begin to sweep down on the rooker as the summer months draw to a close. The number of birds that molt in the vicinity of the rookery varies immensely from one area of the coastline to another, but at Wilkes the number is usually about a quarter of the breeding population, very few being adults that have successfully raised young that year. By the first of April nearly every molter has departed, and the scientist must pack up and return to the main base to sit out the seven months of winter winds and snow.

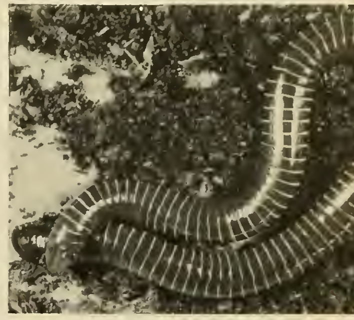
With over fifty years of good but intermittent observations upon the Adélie penguin, new behavioral information continues to emerge. Certainly the story is not complete, and it is hoped that as the Antarctic Bird Banding Program and scientific research continues in the Antarctic many more pertinent questions about this amazing bird can be answered. We are looking forward, for instance, to finding out at what age they first breed. In a land where one observer can only stay for a limited time, it is very important that other interested people in these vicinities look for returns on Adélies that were banded as chicks and have returned to breed. It is also hoped that future trips can be made for a more thorough and controlled study of the various mechanisms and cues that enable this bird to navigate so efficiently to and from the rookeries that are scattered along the Antarctic's seemingly unlimited white vastness.

Skua attacks chick that has roamed from crèche in background. Young can often fight off the predator successfully.

The Legless Tetrapod

Caecilian poses questions for research

By Carl Gans



Despite mouth, nostrils, and eyespots, head and tail of animal look similar.

Few non-herpetologists are aware that there are three orders of recent amphibians—animals often defined as terrestrial tetrapods although many return to water to lay their eggs. Omitting many extinct forms, we have frogs and toads, salamanders, and caecilians. Adults of the first group always have four legs but have no tail; those of the second generally have legs plus a long tail. Caecilians seem to defy the term tetrapod, as they have no legs and only a short, stumpy tail. We still lack details regarding their ancestry, even though study of their embryos and internal structure suggests that they belong to the class Amphibia.

More than a hundred species of caecilians ("blind snake"), or apodans ("no legs") as they were called in some old texts, have been described from the tropics of Asia, Africa, and the Americas. They seem to spend their entire life below ground, burrowing in moist earth, and in masses of rotting vegetation and water plants along the shores of streams and of swamps. The young of some forms are aquatic, as are the adults of one minor group of caecilians.

These animals are only rarely imported to Europe and North America. Temperature extremes kill caecilians quickly, as does dehydration, and few dealers care to risk freight charges on such perishable cargo.

The caecilian shown here was received in an air shipment of burrowing lizards from Colombia, South America. The animal—identified as *Siphonops annulatus*—was a glistening bluish black, with 94 white rings dividing the firm, muscular body into segments. The 18-inch specimen measured ¾ inch at mid-body. It felt slightly moist to the touch, and the skin secretions had an irritating effect when I accidentally rubbed my eye after handling the animal. In spite of the presence of a mouth, nostrils, and rudimentary eyespots, it was difficult to tell the head from the tail. It quickly became used to sterilized, soaked sphagnum moss.

Observation showed that the *Siphonops* would readily eat large earthworms (see photograph, *left*) or night crawlers, generally ignoring slugs, snails, or insects. Ordinarily it kept most of its body underground, leaving just its head and part of the neck exposed from dusk to dawn. The head would be motionless for hours, and only the occasional pumping, breathing motions of the blue-black throat suggested that the animal was alive.

Several questions occurred to the researcher. How did *Siphonops* dig tunnels? How did it recognize its food? Why did it hide for much of the day? One specimen is insufficient to provide satisfactory answers to these questions, but hints obtained by careful observation can always be tested when more specimens come to hand.

Siphonops' head could bend sharply downward to allow the animal to tunnel down at an angle to the axis of the rest of the body. Swings of the head widened the hole, and the skin glands seemed to lubricate the passage. The heavy and continuous bony roof of the skull lies just below the skin and makes such a "head-on charge" possible, but my *Siphonops* was an inefficient burrower, far less effective, in fact, than are many snakes and lizards.

Food recognition obviously does not occur by sight, as the eye can only discriminate light from dark. I could wave an object before the caecilian's nose without a reaction, if I first placed a thin, transparent sheet—film or plastic—between the two. The shield is necessary, as the head is extremely sensitive to touch and minor vibrations. Even air currents may cause withdrawal. There is a suggestion that the head receives the signal that sends the animal underground when it becomes light. My caecilian always hid its head upon withdrawing, but might on occasion leave some portions of the body exposed.

A sense of smell triggers the "hunting" reaction; *Siphonops* will follow objects rubbed with earthworm. It remains to be seen whether the smell is noted by the nostrils or by the "tentacle," a peculiar apparatus located between eye and nostril. In *Siphonops* the tentacle is a tiny pit with a center that may be everted for approximately one-half millimeter.

Only food produced reasonably rapid response from my *Siphonops*. The head angled down and quartered the ground along the trail. The mouth gaped widely the moment contact was made. The open, tooth-studded mouth grabbed the worm at the point of contact and the retreat of the caecilian dragged the worm into the burrow. The grip was sufficient to tear a worm apart. Swallowing occurs at least partly by a muscular peristalsis, and is often accompanied by squeaking or piping noises, the origins of which have not yet been isolated.

As usual, the animal has provided grounds for asking many more questions than the few it has answered. We are now hoping for more specimens, in particular to permit us to investigate further the function of the tentacle.

Dr. Gans, whose work has appeared before in Natural History's pages, is Associate Professor of Biology at the University of Buffalo, and his special interest is herpetology.

On the Track of Wolves

Den observations reveal pack behavior

By Adolph Murie

When only Indians and Eskimo knew the north, the wolf, caribou, Dall sheep, and moose existed together in interior Alaska year after year, century after century. each following its own way of life and each adjusted to the presence of the rest of the fauna and flora. Today these species continue to exist together in the north country, and the presence of the wolf adds immeasurable richness and a wilderness spirit to the landscape. One need not see a wolf to benefit from its presence; it is enough to know that there is the possibility of discovering one on some distant ridge.

My favorite wolf experience took place one day in January some years ago. From a cabin on the lower Toklat River in Mount McKinley National Park, my companion and I started out at daybreak, he on snowshoes and I on skis, each of us carrying a pack containing bedroll and food, enroute to Wonder Lake along the north boundary of McKinley Park. We were making a two-hundred-mile midwinter trip to carry out general wildlife observations. Toward evening it became stormy and we faced into a bitter wind blowing the first snowflakes. By the time we left the river and turned in on a trail, it was dark and stormy. In a few minutes we would have a fire going, a warm cabin, hot coffee, and a big meal. Now we savored the storm, for it made the cabin just ahead seem especially cozy. And then we stopped, transfixed, for out of the storm came music—the long-drawn, mournful call of a wolf. It started low, moved slowly up the scale with increased volume; at the high point came a slight break in voice, then a deepening of the tone as it became a little more throaty. and then a gradual descending of the scale before the soft voice trailed off to blend with the storm. We waited to hear again the voice of the wilderness. But the performer, with artistic restraint. was silent.

The history of the wolves in Mount McKinley National Park during the last forty years is. in a general way, well known. There is also considerable information on the prevalence of the wolf in interior Alaska. although much of this information is conflicting. There is often a tendency to report a great increase of animals if any at all are noted, so that. during a period when wolves were much less numerous than at present. there were many reports of their abundance. Sometimes the caribou, the principal wolf food. shifts its range and brings wolves along with it into new territory, where they are noticed and commented upon.

I suppose the history of wolves varies a little in different parts of interior Alaska. but that the general pattern is similar throughout. Since there are 586,400 square miles in Alaska. of which 3,030 square miles are in Mount McKinley National Park near to the center of the state. it can perhaps be assumed that in its broad aspects the status of the wolves in the park has corresponded closely with that of the animals in interior Alaska as a whole.

Some time after 1908 the wolf population in the Mount McKinley region—and perhaps also in other parts of the interior of Alaska—was considerably reduced. An old-timer who had hunted sheep in the McKinley area in 1916 and 1917 told me he saw no wolves or wolf tracks there during those years. In 1920 and 1921 my

Human predation contributes to the current decline of the wolf populations.

CARIBOU comprise principal diet of the Mount McKinley wolves, which may cache meat when it is scarce, but leave it lying out in the open when plentiful.

THEIR FUR MATTED AND DRIPPING, wet pups stand on boulders in midstream after taking a swim. Wolf tracks are often seen in damp soil of river banks.

brother, Olaus, visited a number of localities in interior Alaska in his travels by dog team and found wolves absent or scarce in most places. In 1927 it was reported that the wolves were becoming more numerous. A band of eleven was noted by one of the rangers. From 1928 to 1941 wolves were reported each year as plentiful in the park, and apparently there were no large population fluctuations during that period. Since 1941, and especially since 1950, wolves decreased—probably largely because of poisoning programs and organized hunting that has been conducted from airplanes beyond the park borders.

In 1940, my second year in the field, I made some effort to find one or more wolf dens. In den hunting, one must turn detective and use every clue available. Unfortunately, some of the clues may only serve to give a false notion of the location. Seeing wolves, if one is fortunate enough to see them, may be suggestive. In the morning, wolf travel is likely to be in the direction of the den, and in the evening, most usually, away from it.

After a fall of snow about the middle of May, I saw wolf tracks on the broad gravel bar of East Fork River directly in front of the little log cabin in which I was camped. The tracks led both up and down the river. I followed them for a mile or more to a point where they climbed a bluff bordering the river bar, and there I surprised myself and a black wolf, a male. He ran off about a quarter of a mile into a ravine and howled and barked at intervals. Following tracks going out to the point of the bluff, I found the den. As I stood four or five yards from the entrance, the female—a gray animal—furtively pushed her head out of the burrow, and then, on seeing me, withdrew. But in a moment she came out with a rush, galloped part way down the slope, and stopped a moment to bark. She loped away and joined the male, and they both howled and barked from the nearby ravine until I left.

From the den issued the soft whimpering of the pups. I wriggled into the burrow, which was sixteen inches high and twenty-five inches wide, to investigate the young. Six feet from the entrance was a right-angle turn. Here the burrow was enlarged to form a bed the female had apparently been using, for it was well worn. From the turn, the burrow slanted slightly upward for six feet to the chamber in which six pups huddled squirming. One seemed lighter in color than the others. I placed her in my packsack to take back to camp and raise for closer observation and acquaintance.

On a ridge across the river from the den and about half a mile from it, I found a good observation point—a view of the den and the surrounding landscape for several miles in all directions. Between May 15 and July 7 I spent many hours watching the home life of this Alaska wolf family. The longest vigil was thirty-three hours, and twice I observed them all night.

A few days after beginning an almost daily watch of the den, I was astonished to see two strange gray male wolves move from where they had been lying a few yards from the den entrance. They rested at the den most of the day. At 4:00 P.M., in company with the black father wolf, they departed for the night hunt. Because I had not watched the den closely the first week, I do not know when the two gray males first made their appearance, but judg-

Position on hillside affords wolves advantage over some prey. From here these four can block escape of sheep fleeing to safety at higher elevations.

Hunting in packs is usual among the wolves, because three or more are able to track down, cut out, and overpower their prey with speed and efficiency.

Although aware of wolves' presence, caribou usually do not run from them unless pursued. Predators most often take weak adults and newborn calves.

ing from later events, it is likely they were there occasionally from the first.

Five days later I saw a second black wolf, a female, making a total of five adults at the den—three males and two females. These five wolves lounged at the den day after day.

I do not know the relationship of the pair to the two extra males and the extra female. The extras may have been pups born to the gray female in years past, or they may have been her brothers and sister, or no blood relation at all. The presence of extra adults is an unusual family makeup, probably an outcome of the close association of the wolves in the band.

Late in July another male joined the group, and a little later a fourth male appeared. These seven, or various combinations of them, were often together in August and September.

Wolves vary considerably in color, size, contour, and action. The mother of the pups was dark gray, almost

"bluish," over the back, and had light under parts, a blackish face, and a silvery mane. She was thick-bodied, short-legged, short-muzzled, and smaller than the others, making her easily recognized from afar.

The father's black coat had a yellowish vertical streak behind each shoulder. From a distance he appeared coal-black except for the shoulder marks, but a nearer view revealed a scattering of silver and rusty hairs, especially over the shoulders and along the sides. There was an extra fullness of the neck under the chin. On the hunts that I observed he usually took the lead in running down the caribou calves.

The other black wolf was a slender-built, long-legged female. Her muzzle was exceptionally long and her neck not as thick as the black male's.

What appeared to be the largest wolf was a tall, rangy male with a long, silvery mane and a dark mantle over the back and part way down the sides. The other wolves approached this one with some diffidence, usually cowering before him. He deigned to wag his tail only after the others had done so. He was also a dandy in appearance. When he trotted off for a hunt, his tail waved jauntily and there was a spring in his step. At times, this excess energy gave him a rocking-horse gallop quite different from that of any of the others.

The other gray male at the den I called "Grandpa" in my notes. He was a rangy wolf of nondescript color and without distinctive markings. He moved as though he were old and a little stiff, and sometimes he had sore feet, which made him limp.

One of the grays that joined the group in late July was a large male. His face was light, except for a black robber's mask over the eyes that was distinctive and recognizable from a distance. His chest was conspicuously white, and he moved with spring and energy. The wolf that joined the group in August was a huge gray animal with a light, yellowish face.

Despite their individualities, however, the group worked in concert. One morning, when the original five adults were lounging at the den, the mantled male became noticeably alert, raising his head to look around at two- or three-minute intervals. Then I saw a strange wolf, a small gray animal, about fifty yards from the others.

All the wolves trotted to the stranger, surrounded it, and for a few minutes I thought there was just the suggestion of tail wagging. But something tipped the scales, for suddenly the wolves began to bite at the stranger, which rolled over on its back, apparently in submission. The attack continued, however, and it scrambled to its feet and with difficulty emerged

from the snapping wolves. Twice it was knocked over as it ran down the slope with the five wolves in hot pursuit. It crossed the river bar, closely followed by the mantled male. When the stranger finally ran from sight, the mantled male returned up the hill, tail held stiffly out behind, slightly raised. When he neared the den the four other wolves ran out to greet him.

Another example of concerted action involved grizzly bears. As a rule, grizzlies and wolves occupy the same range without taking much notice of each other, but not infrequently the grizzlies discover wolf kills and unhesitatingly dispossess the wolves. This loss is not usually a serious matter to the wolves, for if food is scarce the kills will generally be consumed before the bears find them.

When the bears take possession of a kill in the presence of wolves, they are much harassed, but they are so powerful that the wolves must be careful to avoid them, confining their attack to quick nips from the rear.

THE bears are alert, however, and usually the wolves must jump away before they come near enough for even as much as a nip.

One morning a female grizzly and its three cubs appeared on a snowbank about half a mile above the den. The cubs were inclined to wander toward the den on their way to the river bar, but the female held a course down a ravine to one side. On the bar they fed on roots, gradually moving out of view behind a hump of the ridge I was on.

Presently, the black male wolf returned to the den, carrying food in his jaws. He was met by four adults and there was mutual tail wagging. While the wolves were still bunched, a dark object loomed up in the east. It was a grizzly, and it appeared to be following a trail, probably that of the female grizzly with the three cubs. The bear was in a hurry, occasionally

Dr. Murie, scientist and writer, is author of the recently published *A Naturalist In Alaska* (Devin-Adair Co.), from which this piece is taken.

breaking into a short gallop. As it came downwind from the den, it threw up its muzzle, sniffed the air, and continued to gallop forward. The five wolves did not see the grizzly until it was a little more than a hundred yards away. Then they galloped toward it, the black male far in the lead. When the bear saw the approaching wolves, it turned and ran back over its trail, with the black wolf close at its heels. The bear retreated a few jumps at a time, but had to turn to protect its rear from the wolves, which tried to dash in and nip. When all the wolves had caught up with the bear, they completely surrounded it.

As it dashed at one wolf, another would drive in from behind, and then the bear would turn quickly on that aggressor. But the wolves were quicker, and quite easily avoided its rushes. Sometimes the lunge at a wolf was a feint, and in the sudden turn following the feint the bear would almost catch a wolf rushing in at its rear. As it lunged at a wolf, both paws reached forward in what appeared to be an attempt to grasp it; there was no quick slapping with its powerful paws. The target was perhaps too distant for such tactics. After about ten minutes of this the two female wolves withdrew toward the den and shortly thereafter the wolf identified as Grandpa also moved away from the bear.

The black and the black-mantled males worried the bear for a few more minutes, and then the latter lay down about seventy-five yards away. A few minutes later the father wolf also departed. Left alone, the bear resumed its travels in a direction that would take it to one side of the den; but not for long. The black-mantled

Close family unit is characteristic of these animals. Pups of one female are sometimes watched over by another, allowing the mother to join in a hunt.

Drifts give support to young wolves, *left*, that must learn to walk on ice. Both male and female adults seem to be attentive and tolerant toward pups.

Individual wolf coats may be light, black, or some combination in between.

male quickly attacked, and the other four wolves approached at a gallop for another five minutes of worrying the bear. This time the bear turned and slowly retraced its steps, disappearing in a swale about a half-mile away.

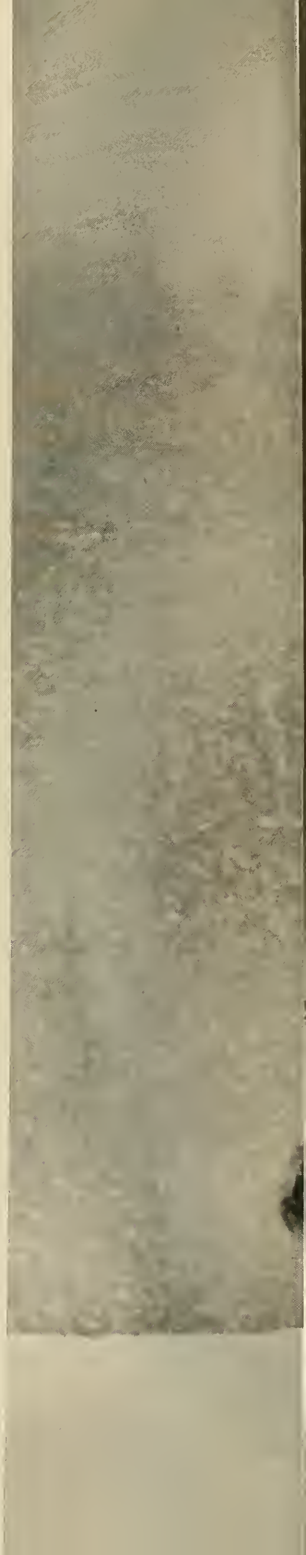
Wolves, in common with most flesh eaters, often cache excess food for future use. When there is an abundant supply, however, food-caching is often omitted. I have found caribou calves left untouched where they were killed on the calving grounds. The wolves had seemingly been aware that there was not much point in caching them, since food was so readily available on all sides of them.

On another occasion, when the bulk of the caribou herds had moved out of the region, and food was not readily available, I observed a hungry wolf voraciously eating a calf for more than half an hour. Then she chewed until a foreleg and shoulder had been severed. With this piece in her jaws, she waded the stream and trotted about three hundred yards up the bar. Here she stopped and, still holding the leg in her mouth, pawed a shallow hole in the gravel and placed the leg in it. Then, with a long sweeping motion of her head, she used her nose to push gravel over the leg. The job was quickly completed, and she trotted back to the carcass, chewed off the head and, this time, buried it about three hundred yards away without crossing the stream. On the third trip she carried another leg and cached it on the side of the river from which I was watching. When she returned to the carcass from this trip, the wind shifted, bringing my scent to her. Without hesitating, she trotted briskly across the stream and up the bar, not stopping until at least half a mile separated us.

At East Fork, some of the food was brought directly to the den, and there I often saw the young feeding on it, but much of it was cached one or two hundred yards away, and some of it as much as half a mile away. The wolf that remained at home during the night went out to these food caches, and occasionally one of the other wolves ate a little from them during the day. Those that hunted probably ate their fill near their kill.

There was considerable variation in the time of departure for the night hunt. On a few occasions the wolves left as early as 4:00 P.M., while at other times they had not left by 9:00 or 9:30. Usually the hunting party consisted of three males, but sometimes one of the females was in the group. The wolves hunted in a variety of combinations — singly, in pairs, or all together. In the fall, the adults and young traveled together much of the time, forming a closely knit pack of seven adults and five pups.

Considerable ceremony often preceded the departure for the hunt. Usually there was a general get-together and tail wagging. One May evening I left the lookout at 8:30 P.M., since the wolves seemed, after some indications of departure, to have settled down again. But as I looked back from the river bar on my way to camp, I saw the two blacks and the two gray males assembled against the sky line, wagging their tails and frisking together. They all howled, and while they howled, the gray female galloped up from the den a hundred yards away and joined them. She was greeted with energetic tail wagging. The vigorous actions came to an end, and five muzzles pointed skyward. Their howling floated softly across the tundra. Then abruptly the assemblage broke up. The mother returned to the den to assume her vigil as the four hunt-bound wolves trotted eastward in the gathering dusk.



Accustomed to northern rigors, these animals face into a mounting blizzard.

Hummingbird Bats

Nectar-drinking Leptonycteris is a cactus pollinating agent

By E. Lendell Cockrum and Bruce J. Hayward

The great majority of bats—and all those that live in the temperate parts of the world—are insect-eaters. Some feed almost entirely on microlepidoptera, others on small diptera (but not mosquitoes), while a few eat large, flightless insects and other arthropods. However, among the many hundreds of bat species, there is a wide variety of diet. At least two kinds of bats, both residents of the New World, have become modified for a diet of fish. Their hind claws are greatly elongated and recurved, and serve as gaffs to capture small fish and shrimp from the water. Some tropical bats are carnivorous, praying on small birds and other bats, while the vampire bats of the New World tropics feed on blood of warm-blooded vertebrates. Still others are fruit-eaters, and several species, surprisingly, eat the nectar of flowers.

Flower-feeding bats are not uncommon in the tropical regions of the world where, at night, they seemingly fill the same ecological niche that is occupied by hummingbirds during the day. Two of these—the long-nosed bat and the hog-nosed bat—can be found as far north as the deserts of the southwestern United States.

The long-nosed bat *(Leptonycteris nivalis* Tschudi) is a member of the family Phyllostomatidae, or leaf-nosed bats. It belongs to the subfamily Glossophaginae, a group that has short, rounded ears, a reduced tail and interfemoral membrane, and an elongated muzzle with a highly extensile tongue. This tongue, which is often as much as a quarter of the total length of the bat, is covered with a series of forward-projecting, bristle-like papillae, making it a perfect instrument for gathering nectar and pollen from deep flowers. The diet of the members of this subfamily varies according to the species. The more primitive forms feed on soft fruits and, to some extent, on insects, while the more highly modified species, with greatly elongated snouts, feed on the nectar of many different species of flowers.

Blossoms of saguaro cactus have nectar that attracts the long-nosed bat; plant's spines sometimes impale the animal.

Saguaros of the southwestern desert, silhouetted against the evening sky, bear night-blooming flowers on tips of arms.

Long-nosed bats alight on stalks of a shin-dagger and work down seeking the nectar. Whitish cast of upper bat's head is caused by abundance of pollen.

Long-nosed bats are found from southern Arizona and southern Texas southward to Guatemala. They are absent from the northern part of this area during the fall, winter, and early spring months, presumably having moved south to areas where flowers bloom all winter. Although several thousand have been banded in southern Arizona during the summer months, none has been recovered during the winter. A few miles from the base of Arizona's Saguaro National Monument is the famous Colossal Cave, where the bats spend the daylight hours during the summer, and where their behavior has been studied for the past several years.

Gravid adult females arrive in southern Arizona sometime between the fifth and the fifteenth of May. They

ongregate in large limestone caves, in naternity colonies of up to 2,000 individuals. Here the young (one per female) are born during the last half f May. Unlike some species, the long-osed bat does not carry her young vith her on the evening feeding flights. Rather, the young are usually transported to a special part of the cave, where they are all placed in a large luster. Banding studies show that the mother recognizes her own young mong the hundreds in these "nurseries." How she accomplishes this is one f the many unsolved mysteries about he animal, for the mother will locate ler own offspring even though it may lave been moved several yards to another part of the cave. The young grow rapidly, and by the end of July have reached adult size. At this time the

EXTREMELY EXTENSILE TONGUE is visible, *above,* as bat approaches open flower.

BAT "HOVERS" at flower for a second or two, *below,* then moves to another.

Dr. Cockrum is with the University of Arizona. Dr. Hayward is on the staff of New Mexico Western College.

maternity colony breaks up, and mothers and young move to other caves in the southern part of the state.

During the existence of the maternity colonies, adult males and nongravid females are found in "bachelor" colonies in still other caves in southern Arizona. From late July until they leave Arizona in late September or early October, there is an intermingling of individuals from the "bachelor" colonies with those from maternity colonies. By mid-October none can be found in the state.

The feeding habits of long-nosed bats are even more fascinating than are their migratory habits. For years the elongated muzzle and the highly extensile tongue have led naturalists to suspect that the bats feed on the nectar or pollen of flowers. Experimental data or observations to support this view were not available. So we examined bats just returning to a roost in the early morning, and found that their abdominal cavities were greatly distended. In fact, one year we wished to confine some gravid females in order to make observations on the birth of the young. Several with greatly distended abdominal cavities were placed in a cage for later examination. A few hours later we were surprised to discover that none of the females was gravid, nor were there any young in the cage. Again, early the next morning, in that cold, dark time just before the first traces of the new day begin to show on the mountain peaks to the east, we noted the presence of many "gravid" females. One of these was injured when we captured her, and when her abdominal cavity was opened we discovered that the stomach was so distended with a clear liquid that newsprint could be read through the walls and the enclosed liquid of the unruptured stomach. The liquid was sweet in taste. We were now certain that nectar was an important source of food for the long-nosed bat, but we did not know what kinds of flowers furnished the nectar. Subsequently, members of the Department of Botany at the University of Arizona identified pollen taken from both stomach and guano samples, and they found that saguaro and shin-dagger *(Agave schottii)* pollen made up the bulk of the grains that were present.

In late May, 1960, a number of long-nosed bats were taken from Colossal Cave and placed in a specially constructed roost box, which in turn was put in a large net enclosure along with a number of saguaros and shin-daggers. Approximately an hour after sundown the bats became active in their artificial roost and, after scratching and clawing behavior that lasted for about five minutes, began to emerge singly. After a few exploratory flights around the cage, they started to feed on nectar of the saguaro and agave blossoms. The presence of observers outside the enclosure did not seem to deter them from normal feeding, nor were they disturbed by a flashlight beam pointed directly at them.

Feeding was accomplished in several ways. The bats often landed at the top of the flowering stalk of the agave and worked downward, inserting their long noses deep into each blossom within reach. Then they moved a little farther down the stalk and repeated the procedure. The saguaro blossoms have a very deep corolla tube, so the bats often grasped the petals with their forearms and feet and seemingly forced their bodies deep into the flower. During this process they carefully avoided the needle-sharp spines of the plant. On rare occasions, however, they apparently do misjudge distances and become fatally impaled.

Another method of feeding consisted of "hovering" in front of the flower, burrowing the head deep into the blossom, and remaining poised for one to two seconds before moving on to another. At such times, their resemblance to a giant hummingbird was astonishing. A number of flowers that had been visited frequently were examined for evidence of damage. None of the anthers had been broken off, nor were there any claw marks on the corolla tube or petals where the bats had grasped them with their feet.

Since it was thought that the flowers in the enclosure might not furnish enough food for the bats present, several saguaro blossoms were filled to the brim with sugar-sweetened water. The first bats to feed at these emerged snorting and with the fur of their heads soaked with the syrupy water. No such problems occurred when the corolla tubes were only half-filled. Even though there was enough syrup to last for a long feeding time, the bats remained at a flower for only one or two seconds, then returned again within five or ten seconds to feed again. This behavior was repeated until the flower was empty. Undoubtedly, if the long-nosed bat could truly hover, it would remain at each flower for a longer period of time, thus expending less energy. From these observations and from analysis of a series of photographs, it appears that feeding is probably a braking motion, and that food must be secured before the forward motion has completely ceased. At the last instant, just before gravity takes over, the bats veer to one side and fly off. If nectar remains in the flower, they return again and again until the supply is exhausted.

Within an hour after feeding began, the animals' heads were noticeably whitish in color, as masses of pollen clung to the fur. This indicated that bats had a great potential as effective pollinating agents. A group of people associated with the College of Agriculture at the University of Arizona and with the Saguaro National Monument were interested in the general problem of saguaro pollination. They studied the flowers, and found that of the 86 saguaro blossoms that opened during the three nights the long-nosed bats were in the enclosure, 53 formed fruits. In other words, nearly 62 per cent were successfully pollinated. Previous experiments had shown that saguaro fruit is never set by self-pollination. Hand pollination resulted in a success of 71 per cent, bees accounted for 52 per cent, and white-winged doves for 45 per cent. (The latter drink the nectar, and their heads become covered with pollen, which is carried to the next blossom.) In other words, the long-nosed bats are considerably more efficient pollinating agents than are bees or birds.

The long-nosed bat and its relatives are truly hummingbird-like in their feeding habits, and represent another of the many strange and little-known interrelationships that exist in the "balance of nature." What we have learned about the animal challenges us with additional questions, not the least interesting of which are: "How far south does this bat migrate?" and "On what other flowers does it feed?"

Flexibility of modified forearm, or wing, is clearly evident in flying bat. Note blood vessels in wing membrane.

Part II

Maya Mystery in Tikal

Continuous occupation of over 1,000 years is indicated

By William R. Coe

Deep in the rain forests of northern Guatemala lie the Classical Maya ruins of Tikal — the greatest of all the Meso-American centers. Since 1956, archeologists of The University Museum of the University of Pennsylvania have been excavating and studying this site, whose vast extent had long been recognized. Mapping has shown that by Late Classic times, from approximately A.D. 600 to 900, the central section of Tikal contained nearly 3,000 structures; inscriptions and other evidence that have been unearthed indicate a continuous occupation of over 1,000 years (see Part I, August-September issue, 1962).

In 1960, most of the excavation effort was concentrated on the North Acropolis — a splendid group of formally arranged, diversely planned Early Classic temples, perched on top of a massive platform. Most contemporary structures elsewhere at Tikal were buried during the building splurge of Late Classic times. However, the North Acropolis survived largely unmodified. It seemed likely that the deepest and oldest levels might reveal the Formative remains of the elaborate ceremonial life of the Maya, which by A.D. 300 had clearly evolved as "Classic."

By May of 1962 an L-shaped trench, 140 feet long, 30 feet wide, and 55 feet deep, had been carried north through the central axis of the Acropolis. Sixteen plaster floors have so far been penetrated, and only the five uppermost ones proved to be Early Classic. In its latest Early Classic form the Acropolis consisted of eleven temples. However, twenty-one buildings, all built on pre-Early Classic floors, have been discovered through trenching. Many of these early buildings had been obliterated in order to make way for new floors and buildings.

Pottery effigy, a remarkable find of the Early Classic period, sits on three crossed femurs and holds human head.

During the 1962 season the oldest, richest tomb yet found in the lowlands was discovered in the Acropolis during the dissection of a small, red-painted platform. The platform had been built on the eleventh floor back through time and had supported a pole-and-thatch building. The platform sealed a deeply cut, crudely vaulted tomb, which contained an amazing array of twenty-four pottery vessels, all of Late Formative types (*ca.* 100 B.C.). An extraordinary jadeite mask with inlaid shell eyes and teeth lay with the pottery on the tomb floor. The startling feature was the individual to whom the tomb belonged. He had been deposited seated and bundled in textile wrappings, but without his head or thigh bones. These parts apparently had been removed as relics before the body was wrapped and buried.

A great mass of additional data is to be co-ordinated with what is now known and is still to be discovered in the Acropolis, particularly that concerning the Great Plaza, which lies between the spectacular Temples I and II, and that of the North Terrace, which fronts the Acropolis. The development of the pivotal, ceremonial nucleus of this greatest of Maya sites will have been exposed, as far as is practical, from Formative to Post-Classic times (*ca.* 500 B. C. to *ca.* A.D. 1400). Trenches and tunnels totaling some 2,000 feet in length will have been dug to satisfy this objective.

Concurrent with studies of the ceremonial portions of Tikal, a great deal of attention has been given to questions of the sustaining population. Some forty-five rectangular, but otherwise featureless, mounds were selected and excavated simply because they were small and up to a mile distant from the ceremonial precincts. Three of these proved to contain the remains of "palaces" — that is, low-lying, usually long, multiroomed structures that, at least theoretically, were used for some administrative purpose. The remaining mounds produced variably constructed, low masonry platforms, which appear to have supported residences. All were built in Late Classic times, about A.D. 800. Proof that these were, in fact, houses is difficult to find in this destructive tropical setting. The assumption is that they were lived in, but by what parts of the population remains conjectural. The diversity in plan and detail of the "houses" suggests an architectural freedom that is quite in contrast with the tradition-bound temples that are found in the central portion of Tikal.

A continuing puzzle is how the corn fields, or milpas, were located in relation to Tikal, and whether the peasantry necessarily resided close to them. What kinds of houses did the farmers live in? The "houses" that have been excavated appear too elaborate or substantial to have belonged to the peasantry, but this is only an impression. There are also constant questions as to the population of Tikal, if only during Late Classic times.

Tikal's limits have not been determined. If, as seems the case, small clusters of mounds continue almost indefinitely, each group with its intermittent ceremonial nucleus, the definition of "city limits" must be determined. Of the mapped 2,750 structures at Tikal, some 2,000 might be of appropriate size and location to have been residences. If they were concurrently occupied and if the average household consisted of five persons, a population of 10,000 is indicated. However, in the light of all these qualifications, a guess of 50,000 or 100,000 would be no less reliable. Population estimates are fascinating mental exercises, but they can reliably be based only on a

STUCCOED BOWL, intricately painted, has a matching cover with bird handle.

RED VESSEL, 16 inches high, *below*, is fine example of Late Formative art.

sampling of the small structures that abound at Tikal as mounds. We are sure that many other small structures existed that have left no surface traces whatsoever. The mounds excavated to date have yielded only the most tentative clues as to the ways in which they served. Social structure, political organization, administrative system, ways of land tenure, and craft specialization remain topics for speculation.

WHAT has emerged in considerable detail is the powerful impact on Tikal of influences from or about the great contemporary Mexican site of Teotihuacán, about 1,000 miles away, and northeast of Mexico City. This influence is most amply expressed

DETAIL of bowl at left depicts head of Mexican deity, Tlaloc, and reflects the strong Teotihuacán-like influence at Tikal in late Early Classic period.

in the sumptuous pottery found in the late Early Classic tombs of Tikal (about A.D. 500). It is still uncertain whether some or all of the vessels were direct imports from Mexico. It is conceivable that they were made at Tikal by Teotihuacán resident artisans or by Maya potters who were very much aware of the modes in highland Mexico. Full technological and artistic analysis should yield the answer.

Tikal's monuments, as well as its pottery, indicate relations with Mexico during this period. One, designated as Stela 32, is especially striking for the fact that the individual portrayed on it in nearly full scale is the Mexican rain deity, Tlaloc, showing features typical of his representations at Teotihuacán. In this case, the apparent insularity of the lowland Classic Maya seems to have been breached. Of exactly what this Mexican or Teotihuacán "contact" consisted is perplexing. Nothing has been found at Tikal to indicate that its ruling faction succumbed to a particular Teotihuacán cult. Nothing points to invasion. While cosmopolitanism might explain a taste for real or copied Teotihuacán ceramics and motifs, it is not easy to explain why Tlaloc, the Teotihuacán deity, was carved on Stela 32, for all to see.

Stela 31 is a further problem. Its hieroglyphic text is entirely Maya. The front, or principal, figure is dramatically Maya. Yet, an incised medallion above the figure's upraised right hand is suggestively Mexican. In addition, the figures carved on the sides of the stela are dressed in Teotihuacán fashion, even to the shield with a Tlaloc displayed on it. The emphasis given the principal Maya personage by necessity subordinates the Mexican figures on the sides. With their spear-throwers and shields, can the foreign figures be considered simply as attendants of a Maya priest? The answer as to the identity of these weapon-bearing dignitaries from Mexico may well

DR. COE, Assistant Curator of the American Section at The University Museum, and the Assistant Field Director with the Tikal expedition, here concludes a two-part article.

lie in the undeciphered, short hieroglyphic inscriptions above each one.

Another important problem has been raised by the excavation. It is now evident that during Classic times many of the great stone monuments of Tikal were destroyed. Intermittent breakage is indicated by the distribution of the fragments of stelae and altars of various periods, and there are some suggestions of a pattern in their destruction. Stela 31 is a case in point. This magnificent monument may have been set originally at the base of a temple that was later buried by a Late Classic structure. The rear room of this early temple became the final setting for the upper two-thirds of the stela, and it seems probable that the heavy fragment was moved up the temple stairway, into the rear room, and to a specially cut pit in the room's floor. The broken underside of the stela appears to have been scorched by a fire burning in the pit. The large fragment was raised and, in a markedly askew position, was stabilized by rubble and a patch of plaster distributed about its new "base." At some point, the faces of the three individuals shown on the stela were mutilated and

GLYPHS on Stela 26 have been saved through the ancient practice of burying

STELA 29, earliest known from Maya lowland, at left, is dated at A.D. 292.

ottery vessels for burning incense ere broken, possibly as a terminal fering to the stela. The vaults of the mple rooms eventually were disman-ed, and the rooms were packed with asses of rubble that obscured the ela. The later building was then con-ructed over the whole temple.

THE quantity of monument frag-ments discovered under less spec-icular circumstances is not easily xplained. If breakage was the result f priestly rivalry or social strife, the ause was surely repetitive. One could eriously question if a Tikal could ave grown, as it obviously did, in the nidst of constant or periodic discord. lternatively, monuments were broken uring Classic times in an apparently anctioned manner. It has been pro-osed that Classic monuments were roken when the structures to which hey related at Tikal were scheduled o be buried by new structures.

Theoretically, the life of a stela may have been governed by the life of the emple at whose base it stood. The stag-gering amount of building carried out by the Maya was, in a sense, a constant hreat to extant monuments. When the

monuments. Little of the details are left on those exposed to the weather.

INCOMPLETE STELA 31, 90 inches high, was found in rubble under later temple.

Mexican rain deity, Tlaloc, appears in nearly life-sized proportions on stela fragment. Identical representations occur at Teotihuacán, north of Mexico City, showing that at some time communication existed between the two regions.

temple was scheduled to be buried, all monuments associated with it were "killed" in a deliberate manner. Various resting places were provided for the fragments, as in the case of Stela 31. Another method of disposal consisted of mixing fragments with construction fill. An area north of Temple III—the source of the now-famed (and incomplete) Stela 29—may have been a dump for substantial portions of various monuments that were deliberately shattered during Classic times. There is no evidence at Tikal that a monument threatened by new construction was moved and temporarily repositioned in a spot considered to be safe.

This tentative explanation for the shattering of monuments might provide a reason for our failure to find monuments of far earlier date than Stela 29, the earliest now known. It has been suggested that the older the monument, the less chance it had to survive intact and in its original position, because of the building fervor of the Maya. Among the fragments now at hand there may exist pieces of such postulated early monuments. The same suggestion allows that no monument with a calendrical text was carved as a permanent record. This transitive quality would also apply to important interpretations recently proposed by Miss Tatiana Proskouriakoff of the Carnegie Institution of Washington. She has discovered hieroglyphic statements of priestly rules on monuments

f certain lowland sites, together with epictions of the priests and, at times, heir families. Should such records be iscovered on the Tikal monuments, a ascinating possibility would emerge—hat of linking the length of a particuar reign to the life span of the comnemorative stela and its related emple. Is there a possibility that the leath of a priest at Tikal resulted in he destruction of his monuments and emple, as well as in his entombment n the temple that superseded his own?

Although much of the makeup of Tikal during Classic times coninues to be elusive, significant insights are being gained. For instance, at about A.D. 700 there was a dramatic shift in the shape and volume of Tikal monuments, as well as in the type of stone used in them. At the same time, here was an abrupt and important change in the offerings set with the stelae when they were erected. Excavations in structures and around the bases of stelae have unearthed some 120 offerings of specially made stone objects, pottery vessels, shells, and other exotic items, which span the greater portion of Classic times. The earliest offerings that were set with the stelae are like those beneath and about contemporary temples. In time, however, "monument caches" very significantly diverged in content from those associated with construction.

The change was slow in both contexts. During Late Classic times, caches set with stelae remained fundamentally alike to the time of the latest local monument, Stela 11, erected in A.D. 869. The long-emphasized conservatism of the lowland Classic Maya is only too evident in the remains encountered at Tikal.

Although excavations to date have failed to expose the cause or causes of the "fall" of Classic Tikal, a good deal can be said of what followed. There is evidence that at some time after A.D. 869 peoples continued to be active among the deteriorating ceremonial precincts. Whoever these people were (there are no signs that they were foreigners), their activities were decadent when judged by Classic norms. Their presence is principally known from their disturbance of Classic remains. Various monuments were uprooted and transported considerable distances. Large fragments appear to have been reclaimed from Classic dumps and replaced in very peculiar positions. An Early Classic tomb within one structure was detected, opened, looted selectively, then filled and sealed over with a thin plaster floor, on which ceremonies involving fire were performed. When the tomb was refilled, considerable cache material was thrown in. Much of this fill stemmed from Late Classic monument caches that evidently had been looted. Sacrifices of censers and Late Classic material were performed about recently repositioned monuments. Small platforms, apparently made of looted ma-

Red pottery dish from Late Classic tomb burial has hieroglyph decoration.

Interior of pottery vessel from early Late Classic period shows a black-and-red fish on an orange background. The piece was in contents of a tomb burial.

Jadeite pendant at left is from Late Classic tomb; mask of same material is from burial of Late Formative times. Latter has shell inlaid teeth and eyes.

DEITIES AND SYMBOLS were incised on obsidian and put in Late Classic caches. Two at upper left are moon goddess in lunar frame and sun god in solar frame.

EXOTICALLY CHIPPED flints were made by Tikal artisans solely for offerings.

sonry, were constructed, and additional censer and fire sacrifices were then made upon them.

ONE can be sure that the opening of caches and a tomb together with the unorthodox re-use of by-then-old monuments were at least in part oriented to ceremonial ends that required the objects and trappings of Classic times. The knowledge of axially positioned tombs and of the existence of secreted offerings had not been lost. The inclusion of cache items in the refill of the tomb suggests an attempt to mollify the individual who had been buried there some 500 years before.

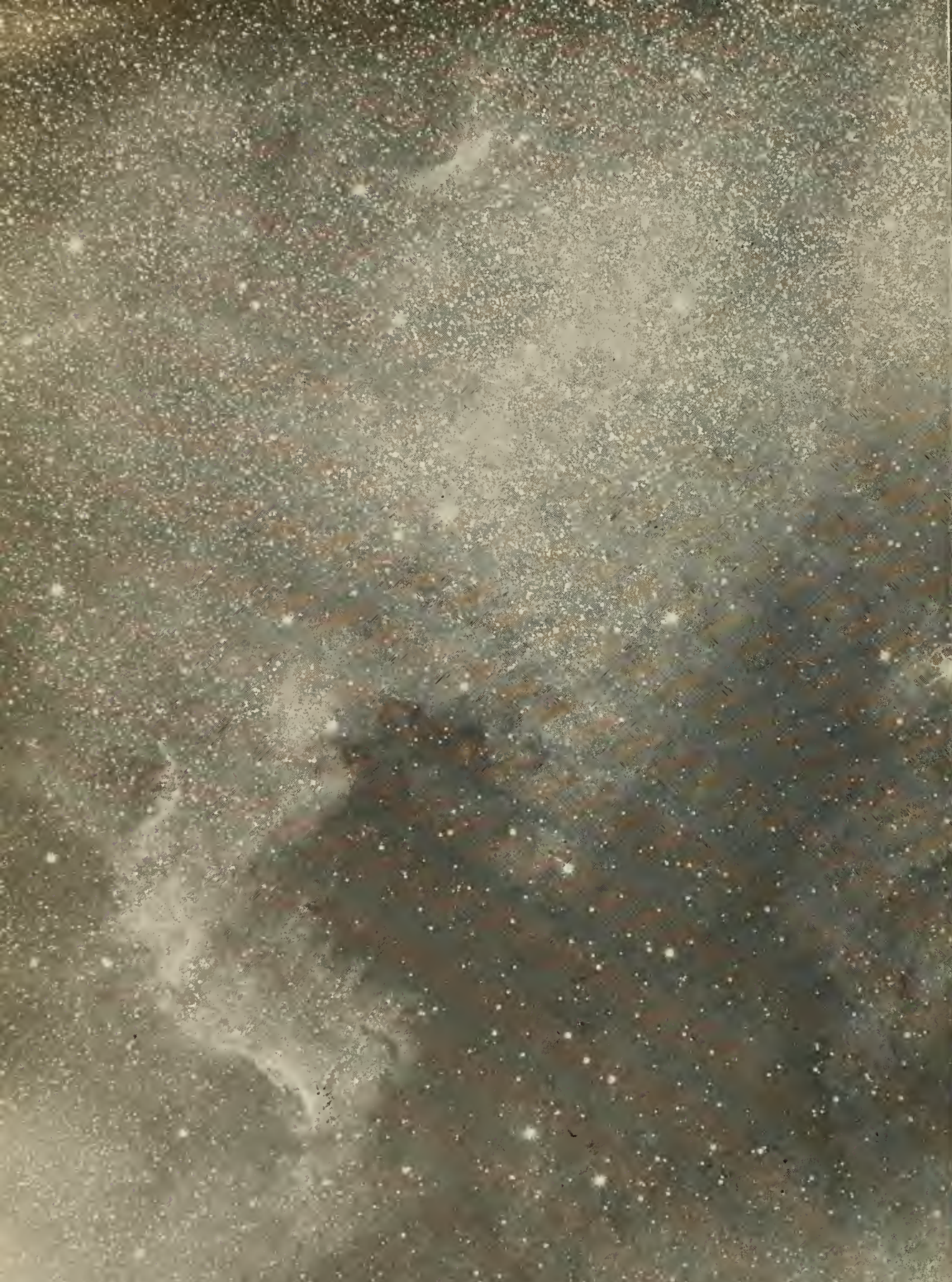
At some time before the close of the fifteenth century, Tikal became the focus for visitations, probably periodic, by peoples of Lake Petén-Itzá, about two days south of Tikal. These people brought pottery unlike that of earlier times. They broke the vessels and burned blue-painted balls of resinous incense in the empty rooms of Temples I and II. In Temple I they dug a large pit through the floor, and in it they buried a woman and an offering of incense and pottery. This hazy phase in the history of Tikal was one in which the site served as a pilgrimage center—an awesome, if not fabled, place of ancestors and, perhaps, gods.

In the latter part of the nineteenth century, some seventy families from Lake Petén-Itzá moved north to Tikal as refugees from the political conditions of the times, but were eventually forced to abandon it. Documents mention rat depredations of corn crops as the reason. This community left behind pottery, glass bottles, a church bell, orange trees, a house foundation, and even a grinding stone (metate) that was made from a salvaged fragment of a Late Classic stela.

THE halfway point has now been reached in The University Museum's program of study at Tikal. The vertical and horizontal immensity of this center is a continual reminder that thoughtful sampling must be a daily aim. Only a small fraction of the mounds and standing structures have been and will be excavated, while even fewer can be considered for restoration. When the program began, we were aware of the problems that we hoped would be answered by excavation and study. Many other unanticipated problems have since appeared, both in excavating and in analyzing the remains. Yet, to find one more reason to ask why, when, or how is to the archeologist no less a discovery than the finds described on these pages.

SHIELD of the side figure of one stela displays head of Mexican god, Tlaloc.

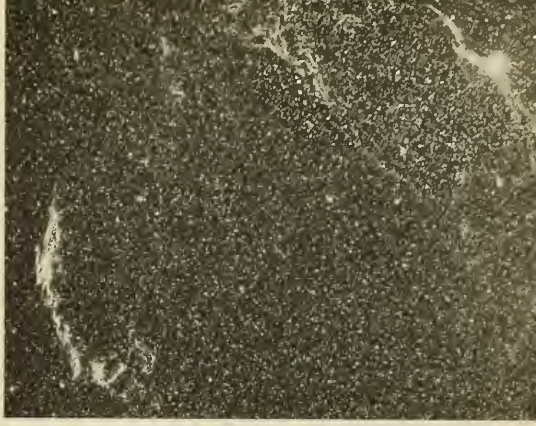
WOODEN LINTELS, placed over doors in Late Classic temples, held up vaults.



SKY REPORTER

Outer spiral arms of northern Milky Way offer varied sights

By Simone Daro Gossner



Veil Nebula may be fragment of supernova that exploded.

The northern Milky Way, from Aquila to Orion through Cygnus, Cassiopeia, Perseus, Auriga, and Taurus, is less impressive, perhaps, than its southern section. None of its star fields can compare with the richness of those near the Milky Way nucleus in Sagittarius, for example. The northern star fields are of interest, however, because they give us a glimpse of the organization of matter in another part of our Galaxy: its outer spiral arms.

If our sun were at the center of the immense pinwheel of the Galaxy, we would see roughly the same kind of star aggregations in every part of the Milky Way. Actually our solar system lies about two-thirds of the way out from the center. Therefore it is not surprising that, looking outward (as we do in fact when we observe the northern sky), we note a gradual thinning of the star fields. On the other hand, spiral arms are rich in hot new stars, dense clouds of opaque dust, and gaseous nebulae, all of which appear in abundant variety to the northern viewer.

Two of the most remarkable regions in this part of the sky are found in the constellations of Orion and Cygnus, which, combined, offer all conceivable types of sky objects characteristic of spiral arms. The Cygnus region lies just to the northeast of the Great Rift, a dark lane of obscuring clouds that seems to rend the Milky Way into two separate branches and continues into the Southern Hemisphere through Scutum and Scorpius. The Rift is so noticeable that it led the English astronomer Sir William Herschel to the belief that the universe of stars was actually forked in that direction. Cygnus itself still bears some traces of the Rift, in the form of two dark patches situated southeast of Deneb and Gamma Cygni, respectively.

The patch near Deneb overlaps a bright nebula in such a way that the nebula's outline bears a striking resemblance to a map of North America (see photograph, *left*). The star Deneb, also called Alpha Cygni, lies just outside the edge of the picture, approximately to the right of the area resembling Newfoundland. On color photographs, the North America Nebula shines with a deep red glow. Spectroscopic studies have revealed that it is not self-luminous, but that its countless particles of dust reflect the light from Deneb. Were it not for the proximity of the bright star Deneb, we would see the North America Nebula only as another dark patch of obscuring material at one extremity of the Rift.

North America Nebula, *left*, bears striking resemblance to an outline map of the continent for which it is named.

South of the North America Nebula lies an unusual object of wispy nebulosity, so tenuous that stars may be seen through it. Called the Veil Nebula, or sometimes the Network (see photograph, *above*), it appears to be self-luminous. The system is expanding as a whole, like a balloon being inflated. It is most probable that the Veil is the remnant of a supernova, like the Crab Nebula in Taurus (Natural History, April, 1962); but judging from the rate of the Veil Nebula's expansion and from the volume it now occupies, the supernova must have exploded at least 30,000 years ago, long before man had invented writing. Therefore, there is no hope of verifying this theory from contemporary records, as was done in the case of the supernova of A.D. 1054, which gave birth to the Crab Nebula.

The Milky Way in Orion (photographs in Natural History, November, 1961) displays its own share of obscuring material, such as the Horsehead Nebula, but is remarkable particularly for its regions of bright, hot gas and extremely young stars. The Orion Nebula surrounds the star Theta Orionis, which is in the middle of Orion's sword. Although Theta, known to astronomers as the Trapezium, appears as a single star to the naked eye, it is actually a system of four very hot stars. As a result, the gas in the nebula is excited to incandescence by the stars' radiation and emits its own light. The North America Nebula merely reflects the light of the much cooler star Deneb.

Orion's region appears to be one of the Milky Way's breeding grounds for new stars. By studying star temperatures and compositions, and the rate at which the stars exhaust their fuel supply, astronomers were able to determine their life cycle. It soon appeared unquestionable that some of the stars in the Milky Way's spiral arms must be very young. Tentative theories were put forth, explaining the mechanism by which stars might form as condensations of interstellar material. It was believed that the process was very slow, and that a man's life would be too short to observe the birth of a star. Recent photographs obtained by G. Herbig at the Lick Observatory may well force a drastic revision of such views. Comparing photographs taken in 1947 and 1954 of a small region in Orion, Herbig noted that where there were five fuzzy objects in the early photo, there were seven in the later picture. A 1959 photograph taken under identical conditions revealed several more.

THE SKY IN OCTOBER

From the Almanac:

First Quarter	October 6, 2:55 P.M., EST
Full Moon	October 13, 7:33 A.M., EST
Last Quarter	October 20, 3:48 A.M., EST
New Moon	October 28, 8:05 A.M., EST

For the visual observer:

Mercury will be at inferior conjunction on October 6, and will therefore be too close to the sun for observation during the early part of the month. In the morning sky after that date, Mercury will reach its greatest western elongation on October 21. The planet will rise 75 minutes before the sun on October 15, and 90 minutes before on October 31. Its brightness will increase from −0.4 magnitude at the time of elongation to −0.8 at the end of the month.

Venus, in the evening sky, will attain its greatest brilliancy (−4.3 magnitude) on October 8. It will set 75 minutes after the sun on October 1, one hour after on October 15, and 15 minutes after on October 31. Early in the month its brightness should make it conspicuous, very low in the southwestern sky soon after sunset. It will be too close to the sun for observation after midmonth.

Mars, moving from Gemini into Cancer (+1.0 magnitude), will rise in the northeast shortly before midnight, local time, October 1, about 11:30 P.M. October 15, and 11:00 P.M. October 31. It will be nearly overhead at dawn.

Jupiter, in Aquarius (−2.3 magnitude), will be found in the southeastern sky after sunset. It will set in the west at 3:15 A.M., local time, on October 1, at 2:15 A.M. on October 15, and at 1:00 A.M. on October 31.

Saturn, in Capricornus (+0.8 magnitude), will also be in the southeastern sky after sunset. It will remain low in the sky and will set in the southwest at approximately 12:45 A.M., local time, on October 1, 11:45 P.M. on October 15, and at 10:45 P.M. on October 31.

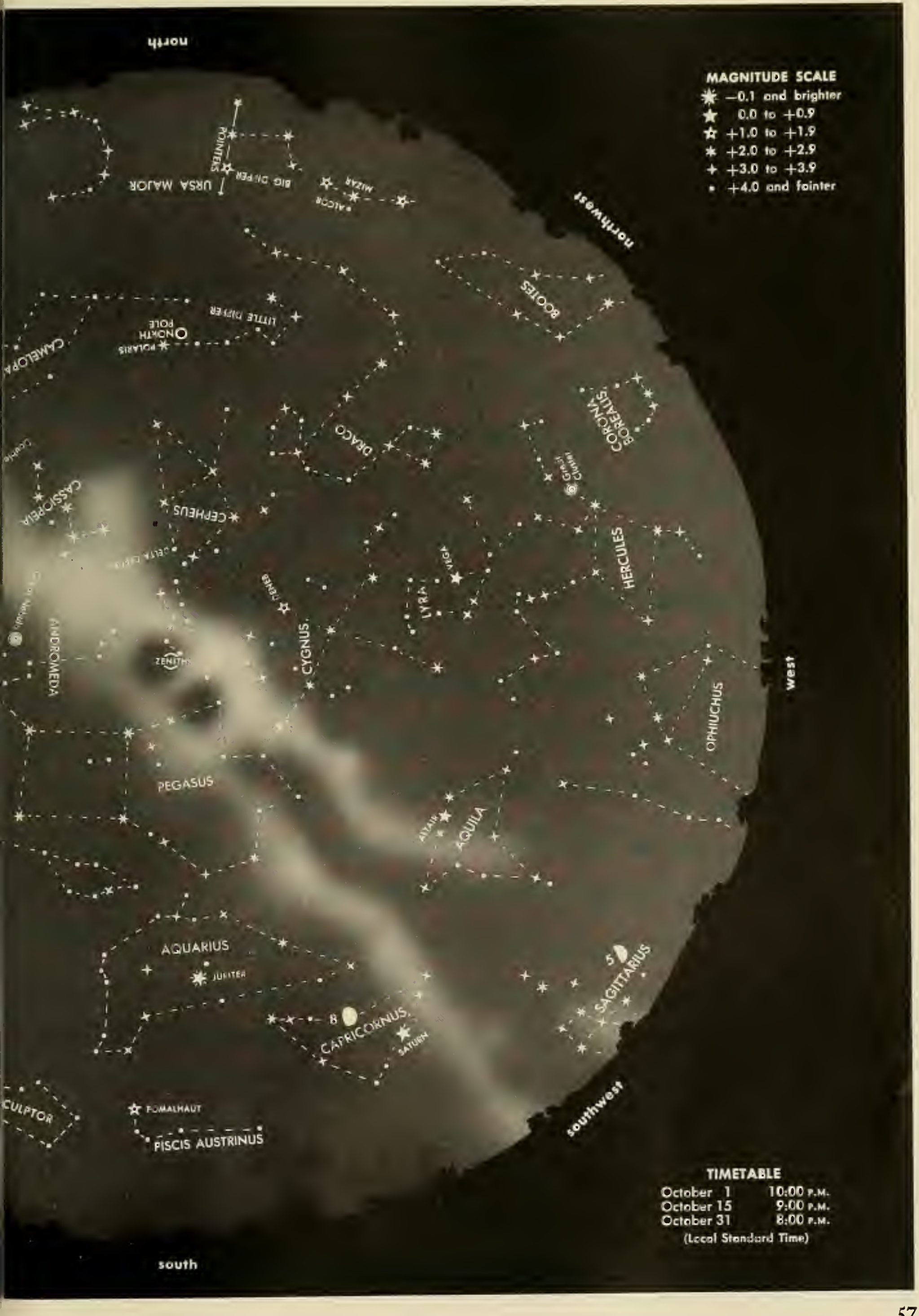
The Orionid meteor shower may be expected on October 20 and 21. In previous years the Orionid shower has reached a maximum frequency of approximately 25 meteors per hour (as recorded by a single observer).

MINOR PLANETS ABOUND

Until the end of the eighteenth century, astronomers had been puzzled by a peculiar gap in the solar system. Bode's law—an empirical rule giving approximate planetary distances from the sun—indicated that there should be a planet at about 2.8 times the radius of the earth's orbit, yet none had been found. This gap was eventually filled when Giuseppe Piazzi, on January 1, 1801, discovered a faint planet-like body traveling at the appropriate distance from the sun. The object was given the name Ceres. Shortly thereafter (1802) a second one—later named Juno—was found in nearly the same orbit. As time went on, dozens more were discovered visually. After the introduction of astronomical photography in the mid-nineteenth century, the number of planets sighted grew steadily until by now more than 1,500 have been observed well enough for their orbits to be computed, and thousands more lie uncatalogued on various sky photographs. These minor planets range in size from 480 miles across (Ceres) to a mile or less, and form a wide belt between Mars and Jupiter.

On the preceding pages, MRS. GOSSNER offers the eighth in her 1962 series—a survey of the celestial sphere.

To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.


north
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
northwest
URSA MAJOR
BIG DIPPER
POINTERS
MIZAR
ALCOR
BOOTES
LITTLE DIPPER
NORTH POLE
POLARIS
CAMELOPA
CORONA BOREALIS
DRACO
Great Cluster
CASSIOPEIA
CEPHEUS
HERCULES
DELTA CEPHEI
DENEB
VEGA
LYRA
ANDROMEDA
ZENITH
CYGNUS
west
OPHIUCHUS
PEGASUS
ALTAIR
AQUILA
AQUARIUS
JUPITER
5
SAGITTARIUS
8
CAPRICORNUS
SATURN
southwest
SCULPTOR
FOMALHAUT
PISCIS AUSTRINUS
TIMETABLE
October 1 10:00 P.M.
October 15 9:00 P.M.
October 31 8:00 P.M.
(Local Standard Time)
south

FAR AND NEAR

A trip through South America provides the traveler interested in wildlife with many opportunities to see creatures that are peculiar to the different environments of a part of the world noted for topographical variety. South America has a remarkable mammalian fauna, and a tourist could well make a zoo-to-zoo and museum-to-museum safari of the continent, interspersed with occasional side trips to view the habitats of the animals—and even, with luck, to see or hear some of the creatures in the wild.

The modern mammals of South America are probably the least-studied of those on any continent. The geologic history of the region indicates long periods of isolation, followed by the appearance of a land bridge and invasion and immigration of mammals from the North. Some of the most exciting evolutionary stories took place in South America, involving mammals so bizarre that even noted paleontologists have complained of inability to visualize the animals from their fragmentary remains.

The present mammalian fauna of the continent thus falls into two groups—the old and the new. The marsupials, the monkeys, the sloths, and armadillos are the old, as are the porcupines and a related group of rodents. All the rest—the cats, dogs, weasels, tapirs, llamas, deer, peccaries, most rodents, and rabbits—are regarded as relative newcomers. And in between is a vast assemblage of extinct mammals that failed to survive because they could not adapt to the competition of the old or the new.

For the mammal-oriented traveler the zoos and museums of South America will provide much information. Most museums exhibit local faunas, but in general they will disappoint the visitor who is looking for magnificent habitat groups. Often the exhibits themselves are older than many United States museums. Although it could not be said that a renaissance is in effect in Latin American museums, efforts are being made in this direction. There is a new mammal hall in the Argentine Museum, which is in Buenos Aires, new and attractive educational exhibits are apparent in Rio de Janeiro, and modern design has appeared in the museum in Belém.

The zoos, too, vary in approach. The zoo in Belém specializes in Amazon animals and has a superb collection. The Mendoza, Argentina, zoo has a fine world-wide collection. It is arranged around a hillside, and there is considerable space between the cages, which edge a spiral walk. Plans are also afoot for a new zoo in Caracas. Many zoos exhibit animals that have never been displayed in the United States, and even a professional mammalogist can view a

Llamas in zoo at Mendoza, Argentina

?are fauna abound in South American zoos

By Richard G. Van Gelder

ıriety of creatures that he has never efore had the opportunity to see alive.

Among the old group of mammals that xist today are the opossums and opos-ım-rats, remnants of a marsupial fauna ıat was once much greater. Even now, owever, eighty species in two families ve South America the distinction of aving the greatest assemblage of mar-ıpials outside Australasia. Two strange rms peculiar to this continent are the ıpok and the *comadreja colorada*. The apok, which is the most aquatic of all ıarsupials, is a nocturnal creature of the mazon Basin. Its tail is as long as the ead and body, and its adaptations to ı aquatic life include webbed feet. The *omadreja colorada*, or red weasel, is ıund both in forest areas and in open ountry in eastern South America, but best-adapted to life in the pampas—ıe vast, open plains of Argentina. It is easel-like in appearance and movement nd is an excellent swimmer. Its color ıriations include flame-red, orange-red, nd terra cotta. Interestingly, an Indian ibe has also named this animal the red easel, although it is a marsupial.

The second old group of mammals in outh America comprises the monkeys. ften thought of first in relation to jun-le regions, primarily in the forests of ıe Amazon Basin. The fossil record is oor because of rapid decay in equatorial forests, but a major delight of southern zoos is the variety of monkeys —sometimes uncaged. For example, in the Belém zoo the visitor may see monkeys cavort in trees and even cling to the *outside* of the cages.

To anyone who grew up with the notion that monkeys always swing by their tails, it will come as a surprise to learn that only five kinds of monkeys have prehensile tails, and that all five are denizens of the American tropics. The familiar organ-grinder monkeys, or capuchins, are perhaps the best-known of these, as they are favored as pets in North America. Spider monkeys and woolly monkeys, both prehensile-tailed, are other petshop favorites. The rare woolly spider monkey of southeastern Brazil can seldom be seen, and is least-known of this group.

The fifth prehensile-tailed monkey is the large howler, which ranges north as far as Mexico. The howling is a dramatic and characteristic noise of the tropical forest, and seems to be associated with the territorial defense of the monkey pack. They also often salute dawn and dusk and the coming of rain. When a downpour begins they stop abruptly, and the jungle echoes with their noise.

The rest of the South American monkeys lack prehensile tails, and come in a variety of sizes and shapes—squirrel-

like marmosets, bearded sakis, bald red uakaries. There is even a nocturnal monkey, the dourouculi. The monkeys can rarely be seen in the wild, but are viewed best in eastern South American zoos.

The third old group of mammals is the order Edentata—the sloths, the armadillos, and anteaters. The armadillos, at least, were in South America in the Paleocene, and they, too, went through a great diversification. Perhaps the best place in the world to obtain an idea of the array of fossil armadillos that once graced the continent is at the La Plata Museum, in La Plata, Argentina, forty miles east of Buenos Aires. There the armadillos' evolutionary radiation is displayed in a huge room that encircles the museum. At least nine genera of smaller (and some not so small) armadillos persist. To a person familiar with only the nine-banded armadillo of our own Southwest, the giant armadillo, with its huge, turtle-like carapace and a weight of more than one hundred pounds, or the small *pichiciego* of northwestern Argentina, which reaches an extreme of phragmosis in using a shieldlike rump to block its burrow, will be particularly interesting.

The great ground sloths are extinct, but their remains are also exhibited in the museums at Rio de Janeiro, Buenos Aires, and La Plata. The living tree sloths are not known as fossils, but a most every zoo exhibits one or bot kinds, although the two-toed sloth i much harder to keep alive because it ha one of the most restricted diets of an mammal—it feeds only on the flower and leaves of the Cecropia tree.

Anteaters, too, are usually well rep resented in zoos—from the giant ant eater with its huge snout and great tai to the tiny, arboreal, prehensile-tailed silky anteater. When ants and termite are in short supply, the anteaters' zo diet is hamburger soaked in tomato juice

These three major groups—marsupi als, primates, and edentates—wer the earliest mammalian invaders o South America. With the exception o the raccoon family, which somehov crossed from North America in the Mio cene before the formation of the presen land bridge, almost all the other existin mammals arrived later, during the lat Pliocene and Pleistocene. The raccoon fall into three groups, the arboreal kinka jous and olingos, the coati-mundis, an the crab-eating raccoon. The last is southern version of our common north ern raccoon, but it is a shorter-haired longer-legged animal with only fain markings. The coatis, on the other hand look like caricatures of raccoons. Th

Three-toed sloth, one of slowest moving mammals, spends life hanging upside down by claws from tree limbs. These creature are exhibited in many South American zoo

OCELOT PACES at Military Academy Zoo in Quito. A fierce fighter, the ocelot is a wild jungle cat. It is found in Mexico as well as South America, down to Paraguay.

ringed tail is there, but it is longer and thinner, and the mask is present on an extremely long-snouted face. The color variations of the coati seem almost infinite, with black, red, and brown predominating. The olingos and kinkajous reveal their relationship to the raccoons only to the anatomist, despite their arboreal and nocturnal habits. Although olingos and kinkajous are anatomically quite different, they seem to be similar in habits and habitats. In fact, both can be found feeding in the same trees at night. Their superficial resemblance is so great that in many places the natives fail to distinguish between them, although the olingo has a more pointed face and the kinkajou has a prehensile tail. One can only wonder how two animals from the same stock seemingly evolved to fill the same niche. Much more study of the two genera, both in the field and in the laboratory, will be needed to answer this question. The visitor to South America who wants to see these animals will have little difficulty finding them, since almost every zoo has kinkajous, and some have olingos. Often the latter are wrongly called kinkajous.

While the emergence of the Panamanian land bridge permitted two-way movements of mammals between the continents, the biological effects seem far more dramatic in the case of those that invaded South America. Seemingly, the northern animals were able to compete far more successfully with the long-isolated, Neotropical elements they encountered in South America than were the South American emigrants able to compete with the Nearctic mammals. The probable reason for the success of the northerners is that they had had a greater history of competition as a result of frequent immigrations and emigrations between North America and Asia across the Bering Strait. In any event, the opening of the southern land bridge heralded the extermination of many South American groups.

The northern animals flowed into all the varied habitats of the continent. Members of the camel family, for example, took to the high Andean deserts and still persist there in the forms of the llama, alpaca, guanaco, and vicuña. Two of these—the short-haired llama and the long-haired alpaca—were developed from the guanaco by the forerunners of the Incas. The animals provided the Incas with transportation, milk, meat, skins, and wool. They are still to be seen in the high altiplano of the Andes, but are being replaced by jeeps, cattle, and sheep. Wild guanacos still haunt the southern Andes and receive some, but generally ineffectual, protection. Vicuñas, on the other hand, were never domesticated; today they are slaughtered by the thousands for the wonderfully soft fleece. In Bolivia, at least, they will not long survive the tremendous hunting pressure.

The pig family was unknown in the Western Hemisphere until introduced by Europeans, but an ecologically equivalent family developed in the form of the peccaries. There are two kinds of peccaries in South America, the collared, which ranges from southwestern United States to Argentina, and the larger and more tropical white-lipped peccary. Like the true pigs, peccaries can plow up the forest floor, and are primarily omnivorous. Although not frequently seen in the wild, they are well represented in zoos.

SOUTH AMERICAN rodents, both old and new, are a delight and a headache to mammalogists. The hundreds of species of mice, rats, squirrels, guinea pigs, and hordes of others are poorly known, and much about them remains to be studied. The chinchillas that have

fur value have been virtually exterminated. and the coypu (called nutria in the United States) is also hunted for its fur. since the animal resembles our northern muskrat in appearance. habits, and pelt. Many of the larger rodents are good to eat. and agoutis and pacas are frequently listed on the menus of the finest restaurants. Some of the larger rodents. including the Patagonian cavy and the striped-faced viscacha, are much-reduced in numbers. Like our jack rabbits, they have been "controlled."

When compared with hoofed animals of the Northern Hemisphere or animals of equivalent latitudes in the Old World, those of South America are unspectacular. The largest land mammal on the continent is the tapir, which reaches a weight of some 600 pounds. Unlike their Malayan belted cousins, the Neotropical tapirs are not strikingly marked, but are plain brown in color. These tapirs are in the lowland forests; in the northwestern areas, the hairy mountain tapir ranges high into the Andes. Various of the hoofed animals may be seen in the Belém zoo, Quito's Military Academy Zoo, the Mendoza, Argentina, zoo, and elsewhere.

There are a half-dozen kinds of deer in South America, all of which probably survive because of their relatively small size and small antlers, which do not attract hunters. In the northernmost parts, our own white-tailed deer exists as a comparatively small and light animal. The Amazon Basin south to Uruguay harbors the marsh deer, a larger species that reaches a shoulder height of three and a half feet. It has antlers about twenty inches—rarely twenty-five inches—long. The pampas deer once had a huge range east of the Andes, but it is now one of the rarest animals. It may have been disappearing even before the arrival of the Europeans, who surely accelerated the process. In addition, there are two very small deer, the brocket and pudu. Both are characterized by tiny spike antlers that rarely exceed five inches in length, even in the larger brocket, which stands only twenty-eight inches at the shoulder. The tiny pudu is half this height, and inhabits the forests of the southern Andean slopes.

The cat family is well represented, from the jaguar, the largest of the New World cats, to the slightly smaller puma, down to an array of small spotted cats—ocelots, margays, Wied's, and several creatures rather like house cats. Other than the puma, there is only one plain-colored cat, the jaguarondi, in this area. It is a little larger than a house cat, is either reddish or grayish in color, has an elongate body, and a relatively long face. It is found in most of South America, and ranges into the southwestern U.S.

DR. VAN GELDER, Chairman of THE AMERICAN MUSEUM's Department of Mammalogy, has traveled extensively in many countries of South America.

DOGS seem to have used our neighboring continent as a proving ground. In the northern regions there is a bulky, squat, grayish "bush dog," which was described as a fossil before being described as a living animal. The foxes are bizarre, the extreme example being the stilt-legged "maned wolf" of central South America. This grass country animal is colored like our red fox, but is about five feet long and stands three feet high at the shoulder. There are several kinds of small foxes, including our own gray fox and a peculiar "short-eared fox" of the southern Amazon and Colombia. Many of the dogs are well represented in various zoos, and the one in Montevideo seems to specialize in foxes.

Considering the variety of unusual animals that may be seen merely by strolling through zoos of cities on one's itinerary, a trip through South America can certainly be considered an eye-opening opportunity for the roving naturalist.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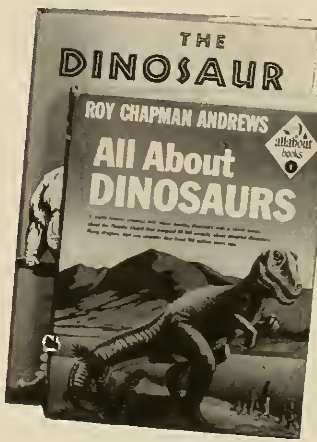
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NATURE and the MICROSCOPE

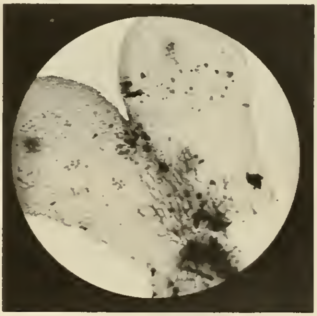
Microexamination of ferns

By Julian D. Corrington

Few subjects included in the botanical sciences hold more interest for novice and expert alike than do the ferns and their modes of life. These plants stand midway in the evolution of their kingdom, with affinities toward the mosses and algae on the one hand, and toward seed plants and flowering plants on the other. An understanding of the organs and tissues of ferns, as seen under the microscope, will help greatly in comprehending the grand evolutionary cycle in the plant kingdom, a cycle first worked out by Hofmeister in 1851.

Hofmeister, a professor at the University of Heidelberg, unraveled the intricate details that would explain the life cycles of liverworts, mosses, ferns, horsetails, and clubmosses. He corrected an old error in classification, based on erroneous views of life-histories. The ferns and their allies were called cryptogams, a word that means "hidden marriage," and flowering plants were called phanerogams, meaning "evident marriage." The phanerogams were so named because the male element, or stamens, in the flowering plants produced pollen grains that were supposed to fertilize the female organ, or carpel, of a flower. The marriage was visible and evident. The cryptogams were thought to propagate in the same manner, with concealed elements.

Hofmeister showed that this theory put the cart before the horse. Actually, the marriage is evident, for all to see, in the cryptogams, but is concealed at the microscopic level in the phanerogams. The plant we call a fern is only one of two alternative generations in the fern life cycle. It is a large, green, leafy plant with an underground stem that puts up compound leaves with many lateral leaflets. On the underside of the leaflets occur greenish structures that later turn brownish. They are called sori. Often, the sori are so prominent that they give the whole leaf a brownish appearance. If such a leaflet is sectioned, it may be seen that the sori house a number of spore cases, each enclosing many brown spores. A leaf that bears these organs is said to be a sporophyll (spore-leaf), and the sorus of such a leaf contains numerous sporangia, or spore cases. Sori may appear on all leaflets or only a few, and at different seasons, according to the species of fern. They could be mistaken

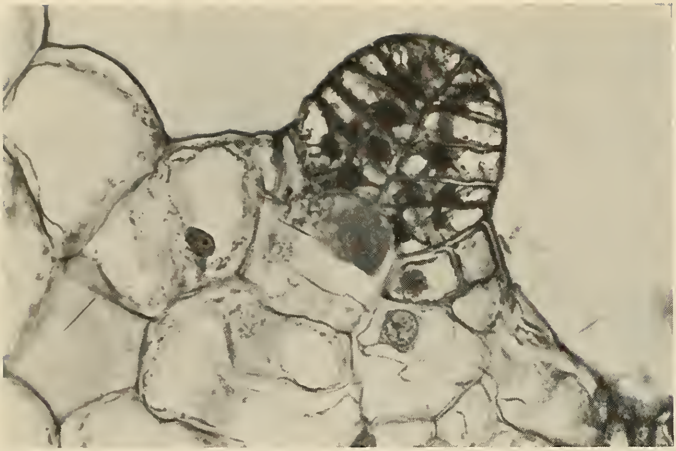


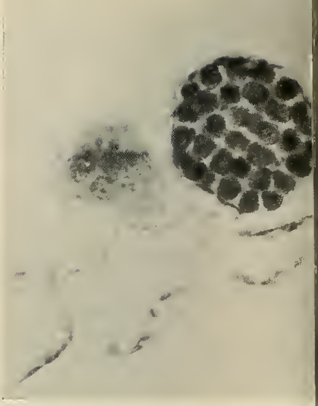
Mature prothallium carries two types of sex organs, at notch and near the center.

for scale insects or some other form of infestation, and are sometimes called "fruiting dots." Cases are frequent in which an irate customer telephones a florist to complain that he has been sold an infected plant, but sori are asexual reproductive organs of all fern plants.

A spore is an asexual (non-sexual) reproductive cell. When it falls upon moist soil, under favorable conditions, it may germinate, but the plant that develops looks nothing at all like our familiar fern. It is a small, notched or heart-shaped greenish body called a prothallium or prothallus, and numbers of these may be seen on the soil or clinging to the outer surfaces of pots in greenhouses where ferns are grown. When mature, each prothallus bears on its undersurface two kinds of sexual organs, which must be magnified to be seen to advantage. One kind, the antheridium, is marginal, situated at the base of the notch. The antheridium will develop sperm cells. The other type of sexual organ is the archegonium, which is found in groups near the center of the prothallus. Each archegonium produces an egg cell. In wet weather, the sperms will swim to and fertilize the eggs. A fertilized egg develops an embryo that eventually grows into the leafy fern plant.

The evident fern plant, since it produces spores, is called the sporophyte. The prothallus is called the gametophyte, since it manufactures gametes (sex cells). The first generation is asex-



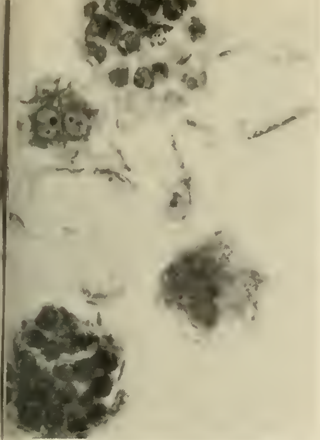


FERN ARCHEGONIUM is shown at left in ar early stage. Antheridium, *right*, produce

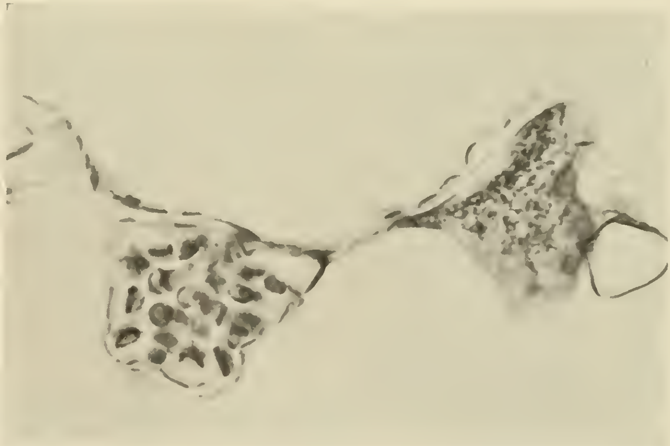
ual, the second is sexual, and there is an alternation of generations, a phenomenon that is almost universal among plants. The leafy fern plant, or sporophyte, cannot reproduce an organism like itself, but only a completely different-looking plant, the prothallus; similarly, the prothallus can reproduce only the leafy fern. Alternation of generations, or metagenesis, is a major factor in the evolution of many of the lower animals and almost all of the plants.

IN the flowering plants, it was Hofmeister, again, who showed that the same alternation of generations takes place. In ferns the spores are all alike (homospory), but in certain clubmosses, as well as in pines and flowering plants, the spores diverge into two types—microspores and megaspores. Sometimes both exist on a single parent plant, and sometimes each type occurs on a separate plant. Microspores develop into a male gametophyte, and megaspores into a female gametophyte. The male and female gametophytes produce sperms and eggs respectively. A pollen grain of a flower is a microspore, and it germinates into a plant within the tissues of the female carpel. The microspore is actually a whole plant generation, although it consists of only a few cells. The same is true also of the female gametophyte, one cell of which is the egg. The sperm fertilizes the egg to make a zygote, and the zygote, surrounded by nutritive and protective tissues, forms a seed. When the seed germinates, a sporophyte is produced. In an elm or a rosebush, the sporophyte is evident for all to see, but only the structural botanist, armed with a microscope can observe the highly microscopic gametophytes, which have become completely dependent and even parasitic upon the all-encompassing sporophytic tissues. The fern has a similar life-history, save that the gametophyte is macroscopic and there is no seed.

AFTER this dose of technical botany we may now proceed to the specific demonstration of certain of these structures. Ferns are widely available, either in the woods or in greenhouses. A whole mount of the underside of a vegetative leaflet may be placed on a slide next to one from the same plant bearing sori. The sori will resemble tiny green or brown volcanic cones. This is one of the



sperms, seen coiled in antheridium. *above,* that fertilize the archegonium's egg cell.



few cases where a dry mount is better than one enclosing balsam or other mountant. Dry the two leaflets slowly over gentle heat or in a low-temperature oven, add a cover glass, and seal the margins of the cover with household cement, balsam, gold size, shellac, or any modern liquid cement. Sori may be scraped from a leaflet, put in tertiary butyl alcohol a few hours, then in fresh tertiary butyl alcohol an hour, then in thin balsam, which is exposed to air until evaporated to mounting consistency.

Next should come a cross section of a leaflet through a sorus, unstained. Details of fixing, sectioning, and (in other cases) staining can be found in any manual of microtechnique. The prothallium makes an excellent whole mount, ventral surface up. Sections through the antheridium and the archegonium on separate slides, stained with the safranin-light green combination, will reveal the cellular details of these structures, showing sperms and eggs. Later installments will describe several of the major techniques used in this work, as well as those employed with animal tissues. End this phase of the cycle with a whole mount of a prothallus bearing the embryo, or a young stage of the sporophyte. Prothallia range from about one-quarter to one-half inch in diameter and, hence, make perfect subjects for slide mounts.

For microscopic preparations of the sporophyte generation, aside from the leaflet showing sori and sporangia, chief interest lies in sections of the stem and leaf stalk, for ferns were the first of the flora to display another great advance in the evolution of plants—vascular tissue. The word vascular refers to vessels, such as the blood vessels of animals. In plants there are two main kinds of these tubular passages, one of which, unfortunately, has come to be called vessel, thus leading to confusion as to whether we are dealing with the general or the particular. The principal tube types are those that transport water upward from the root system to stem and leaf, and those that distribute the nutritive material manufactured in the green leaf, the plant's food factory.

To introduce the subject of the metabolism of the organism, it must first be understood that the only organisms on earth that can manufacture their own organic food out of inorganic materials

are the green plants. They are accordingly referred to as autotrophic (self-feeding). In the presence of chlorophyll, the green coloring matter of plants, carbon dioxide from the atmosphere and water from the soil are combined to make a simple sugar molecule. The process, which uses the energy of sunlight, is termed photosynthesis—putting together materials in the presence of light.

In animals, blood vessels distribute digested food throughout the body. In simple plants, such as algae, no special distributive system is needed. But by the time ferns evolved, the plant body was of such a size—there are tree ferns in the tropics and as fossils in areas now temperate—that some method of transporting metabolic materials became essential. Those tubes so organized as to transport water upward from root to stem and leaf constitute the xylem (wood); those that transport food from leaf to stem and root comprise the phloem (bark). The xylem and phloem are situated side by side in a vascular bundle. The xylem consists of tracheids, which are named from analogy with man's windpipe, or trachea, and vessels. The tracheids are elongate hollow cells, joined endwise to make a tube. The vessels are also made of many cells joined end to end, but with the intervening cell walls at the ends digested away to facilitate water flow. Wood fibers serve as supporting tissue for tracheids and vessels. The phloem is made of sieve tubes plus companion cells and (in flowering plants) adjacent supportive tissue, which is known as parenchyma.

Vascular tissue is characteristic of all the higher plants and makes its first appearance in ferns, where it is simpler in organization than in an oak tree, for example. One of the major schemes for classifying plants divides the entire kingdom into the non-vascular and the vascular. In the latter, a vascular bundle forms in the root, runs up the stem, and out into all the leaf stalks, dividing repeatedly. It so happens that the chemistry of the two chief components of a vascular

Dr. Corrington's column appeared regularly in Nature Magazine for nearly twenty years, and can now be followed in the combined magazines.

bundle differs so markedly that the xylem will stain red with safranin and the phloem green with fast green. Consequently, this staining combination has become famous in botanical microtechnique as a differentiator of the two tissue groups. Cross sections of root, stem, and leaf, stained first with safranin and then counterstained with fast green, yield brilliant, contrasty slides that easily distinguish these essential parts of a vascular bundle, the xylem and the phloem.

Ferns were the first plants to develop the three principal organs or parts of plants as seen in higher groups: root, stem, and leaf. Except in tree ferns and a few aquatic species, the stem is horizontal and underground, and is known as a rootstock or rhizome. It gives off leaves vertically upward and roots vertically downward. The leaves are compound, with side divisions that are called leaflets. Ferns began in the Devonian, and throughout the Carboniferous they were among the dominant members of the plant kingdom. In coal mines one comes across coal balls, rounded concretions that can be split into layers to reveal fossilized portions of former ferns and their relatives. Parts of stems and leaves are also commonly found in split plates of coal. A large number of fossil genera and species have been described. Hence ferns, ancient in lineage, make an excellent introduction to botany.

This list details the photographer, artist, or other source of illustrations, by page.

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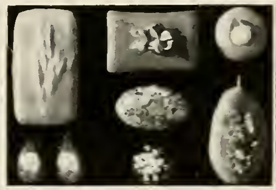

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THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY

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COVER: This carved argillite panel shows, at the top, a raven facing a bear from whose ear a frog emerges. The piece, in the collection of The Brooklyn Museum, was made by a Haida Indian during the last half of the nineteenth century, and the intertwining of figures, typical of Northwest Coast art, is beautifully demonstrated in this colored example. Other pieces, which are in collections of The Museum of the American Indian and The American Museum, were photographed especially for NATURAL HISTORY. They will be found, together with a discussion of the evolution of this Haida art form, on page 30.

The American Museum is open to the public without charge every day during the year. Your support. through membership and contributions, helps make this possible. The Museum is equally in need of support for all of its work in the fields of research, education, and exhibition.

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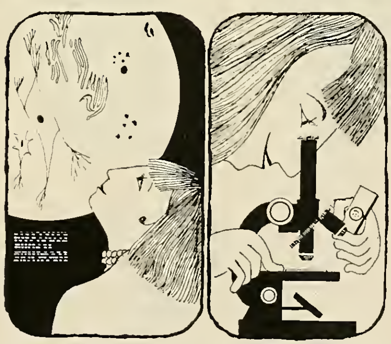
MUSEUM MEMO

There are several rooms in The American Museum of Natural History that display no exhibits, contain no laboratory equipment, have no collections, but represent, nonetheless, some of the most important space in the Museum's twenty-three acres. These are the meeting rooms in which Museum scientists exchange ideas with one another and with their colleagues from all over the world in a continuous symposium. One of the most fruitful of these exchanges occurred this year when a week-long conference on the use of telemetry in the study of animal behavior and physiology was held at the Museum. Biologists and engineers from many parts of the country assembled to discuss the use of instruments such as miniature radio transmitters to trace the movements of Antarctic penguins, grizzly bears, woodchucks, and other animals. They noted the progress that has already been made in the use of tiny instruments for studying biological functions in aerospace medicine, and agreed that telemetry has exciting potentialities in studies of animal behavior and ecology. Cosponsors of the conference were the Museum, the Office of Naval Research, and the Foundation for Instrumentation, Education and Research, in cooperation with the American Institute of Biological Sciences and the Instrument Society of America.



Another of the groups that met at the Museum last year was the International Council for Bird Preservation, which is the oldest international organization for conservation in the world. Delegates came from Europe, Latin America, Central Africa, Hong Kong, India, Canada, Japan, Iceland, the Union of South Africa, the Philippines, and Malaya. Their discussions included reports on the use of pesticides, the pollution of the seas by oil, and birds in danger of extinction. As one press representative pointed out, the importance of birds as a continuing subject for friendly international discussion was apparent at both the formal and the informal gatherings.

Members of our own staff also traveled to distant parts of the world, frequently combining scientific meetings with field research. One of our scientists waded through the surf off a tropical island in the West Indies while making a geological survey. Another crawled along the floor of the Panamanian jungle observing the behavior of a poison frog. An astronomer of The American Museum-Hayden Planetarium made telescopic photographs of the stars from a mountaintop at the Southwestern Research Station in Arizona, and an ornithologist thrilled to his first observations of the spectacular rifle bird in the wilds of Australia. In a remote region of the Canadian Rockies, one of our paleontologists excavated the fossil remains of fishes that lived 200 million years ago, while halfway around the world another paleontologist reveled in the rich fossil reptile collections of South Africa.

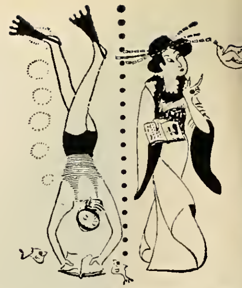
The creative research of the staff, fostered by exchange and field work, is in turn reflected in our exhibition program. Last year, more than 2,500,000 visitors saw the diversified exhibits by means of which the Museum interprets scientific knowledge gained from its collections and research. The influence that a good exhibit has on its viewer cannot be underestimated; a person spending an hour or so in a Museum hall often finds that the experience has kindled a lifelong interest in the subject.

These are the major concerns of this Museum—the acquisition, exchange, and interpretation of knowledge. But within this framework we have a keen and continuing interest in the very future of knowledge itself, and certainly the future of knowledge lies in the hands and minds of the young people of today. Among the year's participants in the several Museum programs designed to encourage and strengthen scientific interests in young people were budding biologists, anthropologists, geologists, and astronomers. Typical were a 17-year-old high school lad who enrolled in the special training program in astronomy and space science, cosponsored by The American Museum-Hayden Planetarium and the National Science Foundation, and a 19-year-old college girl who assisted a Museum scientist in the Foundation's Undergraduate Research Program. The boy, whose primary interests are biology and physics, plans to specialize in astrobiology in college and dreams of the contributions he can make to manned space explorations. The girl, a biology major, plans to go to medical school and become a research pathologist.

A boy and his dream of exploring space; a girl with a goal of helping mankind through medical research . . . the future of knowledge depends on such beginnings. At The American Museum we view this future with enthusiasm.

Alexander M. White
President

Reviews



"Field guide fashion" spreads through world

By Francois Bourliere

The present-day "field guide" concept originates in the pioneer field guide to the birds of eastern North America, published twenty-eight years ago by Roger Tory Peterson, that unique blend of artist and naturalist who has probably done more than any of his contemporaries to revive the interest in open-air biology that characterizes our time. As a matter of fact, species recognition based on carefully selected field marks has made possible a number of behavioral and ecological studies that would have been quite unthinkable a generation ago. Such guides for the layman have made field work attractive and appealing, and have been largely responsible for the growing interest in nature and conservation, now so apparent all over the North American continent.

Future historians of natural sciences will probably come to the conclusion that the development of this new technique of field determination played a trigger role in the "boom" of contemporary vertebrate biology. The most brilliant concepts of community or population ecology would indeed remain quite unverifiable if the various species could not be accurately identified, sexed, aged, watched, and counted on the spot, without disturbing their activities.

It is therefore comforting to see that the field guide fashion is rapidly spreading out of its mother country to many other parts of the world. Most of the European countries have presently their own field guide series. An attractive *Zoogdierenguids* by F. H. van den Brink, with plates by Paul Barruel, covering all the mammals found west of the Ural Mountains, was published by Elsevier in Holland in 1955, and a revised German edition was issued in 1956. Last year *Die Unterwasserfauna der Mittelmeerküsten*, a revolutionary guide for the Mediterranean skin diver and underwater naturalist, was written by W. Luther and K. Fiedler and published by Paul Parrey of Hamburg and Berlin, Germany. Its 32 color plates of coastal fishes and large invertebrates executed by Gertraud Hofmann are among the best ever painted and printed. It even contains four extra (plastified) *Unterwasser-Tafeln*, which can be taken under water by the diver to assist him in identifying the most common fishes. A similar volume written for the Florida and West Indian underwater naturalist would certainly meet with great success. In South America, Claes Chr. Olrog wrote a pioneer field guide to Argentinian birds *Las Aves Argentinas*, Tucuman, Instituto Miguel Lillo, which, despite its sketchy and crude color plates, is a considerable aid in identifying the birds of the southern third of the continent. James Bond's *Birds of the West Indies* (beautifully illustrated in color by Don R. Eckelberry) and G. A. C. Herklots' *The Birds of Trinidad and Tobago*, published by Collins, London, although not true field guides, are also valuable additions to the library of the Old World naturalist in these parts of the world. Other titles are also in preparation, including one mammal guide for India and bird guides for both East Africa and Mexico.

But the most ambitious set of field identification books was not published in the Western Hemisphere or in Europe. It comes from Japan, where in a few years twenty-four volumes have been issued by the Higashi-Ku Publishing Company of Osaka. These guides constitute a most remarkable accomplishment, demonstrating not only the high standards of production of natural history books in Japan, but also the remarkably high "average level" of their amateur naturalists in various fields.

The complete list of the titles available to date shows the extensive coverage of the existing volumes (some already in their second edition!). Apparently, the only gaps are the reptiles-amphibians volume, the second part of the fish guide, and the last volume on herbaceous plants. Every volume is, naturally, written in Japanese, but each bears a bilingual (Japanese-English) title page, and every species illustrated bears a number referring to the Latin name as quoted in the text. For the Western reader, unable to read the Japanese text, these volumes will nevertheless be most useful, acting as illustrated color-atlases of the Japanese flora and fauna.

What makes this series outstanding is the quality of the color plates. Whether they reproduce color photographs (as is

Eminent ecologist M. Bourliere is also Professor of Medical Biology at University of Paris' medical school.

the case with the volumes on butterflies, moths, and shells, for instance) or water colors (as with mammals, birds, fishes, plants), the accuracy of the colors and the sharpness of the engravings are amazing. The format is pleasing, although a little too large for the usual Western pocket. The binding is strong and every volume is sold in a tough cardboard case. Nothing similar has ever been published (for so low a price) in Europe or North America.

The extensiveness of the coverage varies considerably from one group to another. All the species of mammals and birds recorded from Japan are included in volumes 6 and 7: 199 butterflies and 2,678 moths are illustrated in volumes 1, 21, and 22. About 1,200 shells are figured in volume 4, and 627 species of marine invertebrates are shown in volume 8. Volume 5 (part 1), on the other hand, figures only 312 species of fishes. The botanical volumes appear to cover quite extensively the various species of flowering plants, ferns, large mushrooms, and algae indigenous to Japan.

THE STORY OF MAN, by Carleton S. Coon. Second Edition (revised). *Alfred A. Knopf, $7.50; 438 pp., illus.*

In *The Story of Man* Carleton Coon has undertaken no less a task than a survey of the human adventure, from the first appearance of manlike creatures a million or more years ago right up to the present atomic age. He has done this in but little more than 400 pages—certainly a record of compression except for a number of aphorisms that after all are not comparable. He has been able to do this by eliminating the personae of history, by avoiding dynastic and other political machinations, and by ignoring generally the highroads as well as the bypaths of conventional history. By adopting Leslie White's concept of the evolution of culture as an expression of the increasing energy potential man has discovered how to use, Coon has provided himself and the reader with a means of tracing the course of human progress. This makes for a very reasonably objective approach to an otherwise highly complicated history that others have taken volumes to tell and without covering as much of a time span. For Coon starts with the biological beginnings when the only energy available was man's own muscles.

There are inherent difficulties with an assignment as sweeping as this in time and as succinct in space. In the earlier story the facts are few and in the later ones they are overwhelmingly abundant. Both situations present pitfalls for a book of this sort. In the former, an author might find himself frequently tempted to infer too much from the few bones and the simple stone arti-

facts available. This is especially true when writing for a general public not conditioned to find in the technical problems the fascination they present for the specialist. It is hard under the circumstances to resist putting some flesh on the bones and to refrain from inferring too much from the artifacts. Unfortunately, in this lively tour de force Coon has fallen too frequently into this trap. thus marring a performance of great merit. Occasionally we even find inference canceling inference. For example: "Of the communication of Upper Paleolithic and Mesolithic man we know almost nothing except that Upper Paleolithic hunters apparently kept count of their seasons' kills on notched sticks. These tallies may, however, have been formal invitations to a wedding, with the notches indicating the number of days to elapse before the ceremony. Australians make such message sticks."

In the later periods, the reader may find the generalizations for brevity too general to mean much. There are even such comments as this: "Twenty years ago the average American household consisted of a father and mother and three children, with one maid who slept in the attic and worked in the kitchen. Often a hired man mowed the lawn and tended the furnace." I guess most of us were subaverage 20 years ago!

Perhaps these imperfections are inevitable, or perhaps they stand out because so much of the rest of the writing is excellent and thought-provoking.

HARRY L. SHAPIRO

MUSHROOMS AND OTHER FUNGI, by H. Kleijn. *Doubleday & Co., $10.50; 144 pp., illus.*

For a number of years popular books on fungi, especially those with color illustrations, were few in number and difficult to obtain. Within the past 10 years, however, several well-illustrated books on fungi, written by competent authors, have appeared. This one, by H. Kleijn, president of the Royal Society of Natural History in Amsterdam, is unsurpassed in beauty. It contains 94 color photographs of fungi in their natural habitats. Although it treats European species, many also are found in North America or have close relatives here.

The brief text (31 pages) and the abundant photographs are nearly independent of one another. This leads to mechanical difficulty when one attempts to read the text, for each page of copy is separated from the next by three pages devoted to pictures and captions. The inconvenience is compensated partially by the high quality of the photographs, captions, and text.

One shortcoming of this book is that no attempt has been made to adapt it for an American audience. The American lay reader will find a number of unfamiliar common names (for example paunch fungi for puff balls, stinkhorns and earth stars; spine fungi for tooth fungi). Other European usages are also prominent, such as lime for linden and electric torch for flashlight. Terminology also is loose, including the use of "stem" for the stipe, or stalk, of a mushroom.

The colored photographs are excellent close-ups of the conspicuous spore-bearing bodies of fungi. Two improvements that might be added are an indication of the scale, for the degree of enlargement or reduction of the illustrations varies widely, and some comment on the distribution of each species. The few line drawings are neither adequately labeled nor well integrated with the text, which is composed of interesting accounts of the historical uses of fungi, legends about them, a brief description of the structure and growth of the plants, and an outline of fungus classification. The description of the life cycle of a fungus is incomplete, perhaps because of some mistaken opinion of author or publisher that the layman does not want,

or could not comprehend, the few additional details that would both clarify the story and increase its interest.

For those who wish a brief, readable, and authoritative account of the larger fungi plus a superb album of nature photographs, this book has much appeal. For those who desire a book to aid them in identifying the fungi they may see in the lawns, fields, and forests around their homes, it will be of only slight value.

JACK MCCORMICK

OUR WILDLIFE LEGACY (Revised Edition), by Durward L. Allen. *Funk & Wagnalls Co., $6.50; 422 pp.*

THE changes in this revised edition are minor, and are intended mainly to bring up to date what was justly acclaimed some years ago as one of the best (if not *the* best) books on wildlife in relation to contemporary human society. Durward Allen writes with ability and with readability from his knowledge of biology and related subjects—a rare combination in this specialized field.

In this edition, Dr. Allen is still driving toward the same goal—with the quiet persuasion of incontrovertible fact he wants to dissolve the vast mass of misinformation, sentiment, and prejudice that has built up in the public mind about man's relationships with other animals on this planet. Since these relationships are practical, often subject to regulation by law, the issue is urgent.

As Dr. Allen points out: "Wildlife is one of those *renewable* resources that must be *managed* if we are to have continued benefits from it. The whole people have a common interest here. Many of them feel this intensely and they want to do the right thing. But specifically how can they serve that interest? In terms of the public weal, what is sound . . . ?" Dr. Allen comes as close as anybody can to answering those questions.

PIETER FOSBURGH

FLOWERS OF FIELD AND FOREST, by Clarence J. Hylander. *The Macmillan Co., $4.50; 231 pp., illus.*

THIS is a good book, and it goes far beyond the field guide category suggested by the title. In this book, Mr. Hylander is more an ecologist than a botanist (although he is always both), and tells where to look for plants as well as how to identify them.

"You would never think of looking up someone in a strange town without knowing his address. The habitat . . . of a wild flower," according to Mr. Hylander, "is its address; when you know this, you have

some idea where to look for it."

Then he groups flowers as they are found across the country, separating them by habitat, by color, and by construction, wherever they may be found. This is not a big book, and Mr. Hylander has selected only some 200 species of wild flowers for discussion and illustration. But these are used to acquaint the reader with the various types of plant communities as they exist throughout the country, and with the environmental conditions that make possible such existence. With this knowledge in hand, the reader may then proceed to personal inspection of any one of these communities, and here the author's simple rules for identification will prove most useful.

"To be able to call a flower by its correct name is a satisfying achievement," he writes. "But it becomes even more satisfying when you recognize the flower as a living thing with 'likes' and 'dislikes,' and have learned why it is able to live where and how it does."

Most wild flower field guides—and there is a plethora of them—describe at least briefly the environment in which a particular species may be found, but the emphasis is on the flower itself. Mr. Hylander reverses the emphasis, and we progress from environment to flower. This simple, unpretentious work is short but effective, and fully realizes the hopes of the author to give "a dynamic viewpoint of plant life; and understanding of the relationship between a wild flower and its environment. . . ."

PIETER FOSBURGH

THE WORLD OF ICE, by James L. Dyson. *Alfred A. Knopf, $6.95; 292 pp., illus.*

HERE is a long-needed, comprehensive treatment for non-specialists of the fascinating subject of glaciers and changing climate, permafrost, and icebergs. Beginning with the discussion of snow line, perennial snow fields, and the mechanisms of birth and movement of glaciers, Professor Dyson proceeds to the characteristics of mountain glaciers and continental ice sheets. This is followed by excellent coverage of sea ice, icebergs, and permafrost—subjects that are too often overshadowed by the more spectacular manifestations of land-based glaciers, but to which Dyson justifiably devotes fifty pages (more than one-sixth of his book). After providing the reader with this background, the author looks at the evidence, meteorological, geological, and biological, for climatic change in the present, in the historical past, in postglacial time, and, finally, during the Pleistocene Ice Age.

Dyson very clearly and concisely presents a tremendous amount of information. In just 274 pages he discusses not only the essentials but also many of the innuendoes of scientific interpretation of glacial phenomena. At the same time he has sprinkled the book liberally with cultural activities associated with the world of ice, such as pursuit and identification of the mysterious Himalayan Yeti, destruction of Alpine villages and farms by medieval glacier advances and by modern-day avalanches, and the rigors of polar exploration. The completeness and objectivity of Dyson's treatment are quite satisfying to a glacial geologist, who wonders, however, if the non-specialist might be left behind at times—for example, as the author breezes through the concept of glacier movement. Perhaps a few line drawings would have been helpful at this and other places. Fortunately, the author includes an excellent bibliography and glossary.

The photographs are of outstanding quality and are well chosen to illustrate many features that the author discusses. However, the reader would have benefited even more if the photos were referred to at critical points in the text.

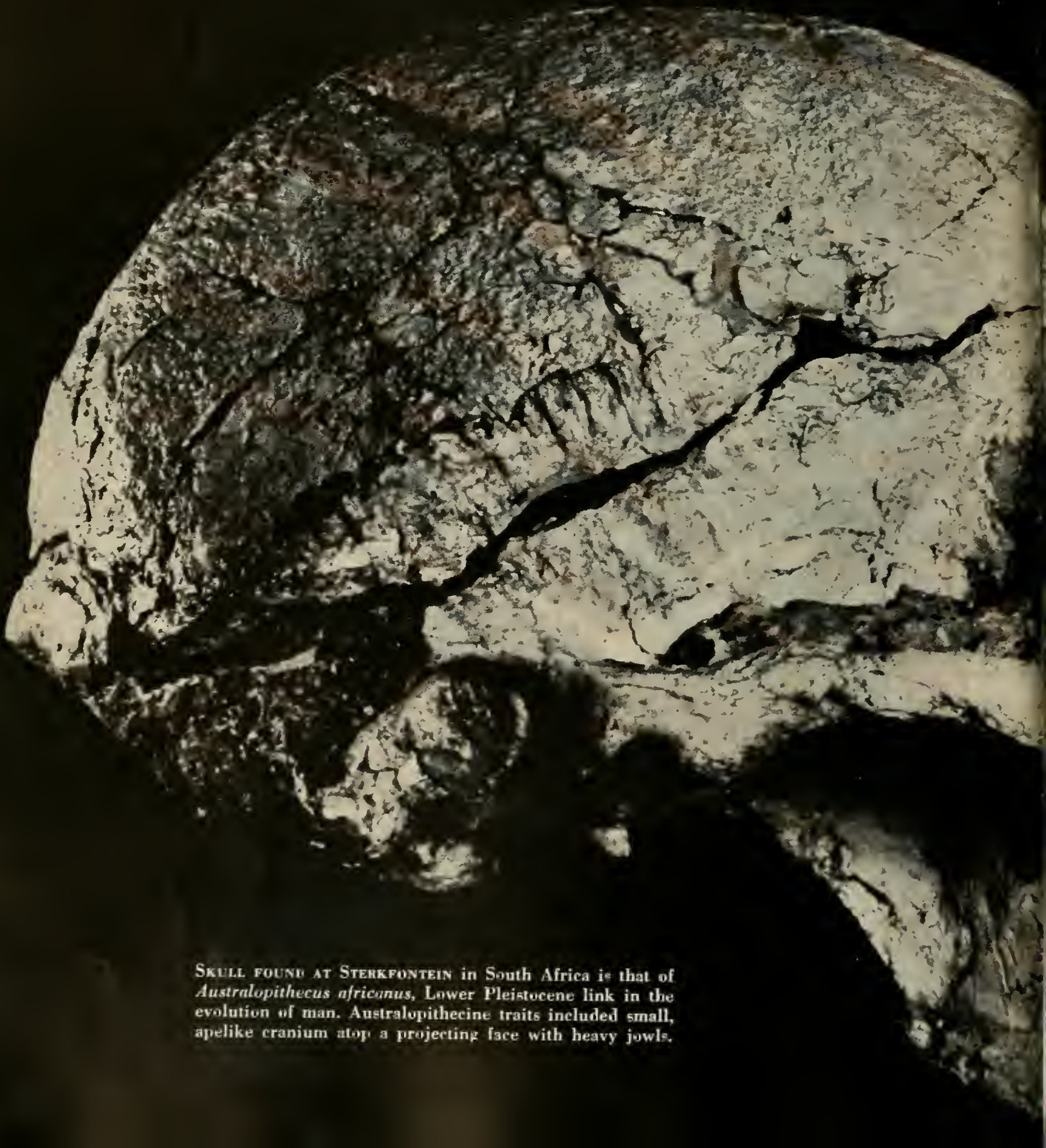
The final chapter includes interesting speculation about future encroachment by continental ice sheets into populous areas of the Northern Hemisphere. For nearly the first time in popular print we read that such advances will not be catastrophic, and, moreover, that people of the future will scarcely be aware that they are retreating before an advancing ice sheet, although the docks in New York Harbor may end up halfway across the continental shelf.

Dyson's coverage is fully up to date, including International Geophysical Year observations and even the cable car accident that occurred near Mont Blanc in 1961. This book should completely satisfy the curiosities of the numerous individuals who like to speculate about our changing climate. It is especially recommended as an antidote to perennially recurring "crackpot" theories on catastrophic causes and consequences of ice ages. Professor Dyson draws widely on his own travels and experiences to present in a clear, non-technical fashion his appealing narrative about the fascinating world of ice.

WILLIAM R. FARRAND

Emerging Man in

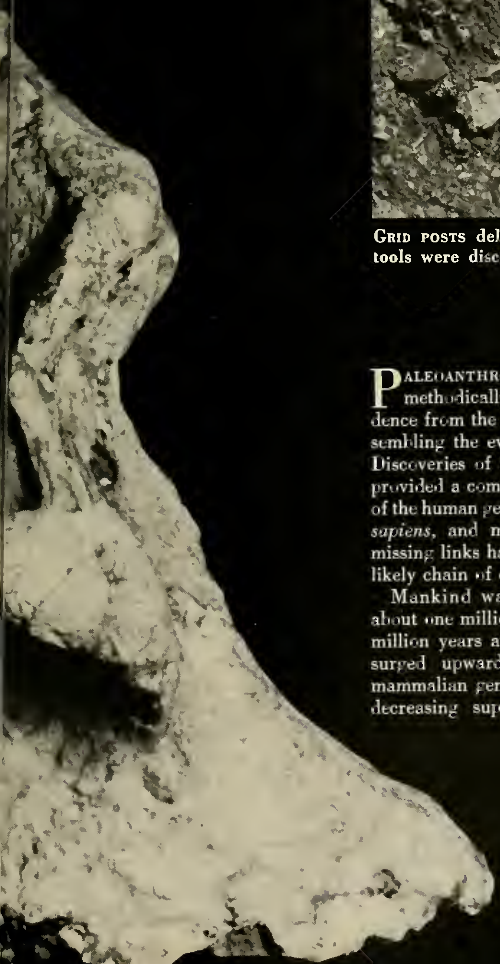
Recent finds provide more clues to the origins



SKULL FOUND AT STERKFONTEIN in South Africa is that of *Australopithecus africanus*, Lower Pleistocene link in the evolution of man. Australopithecine traits included small, apelike cranium atop a projecting face with heavy jowls.

Africa

of early man



Grid posts delimit area where stone tools were discovered at Sterkfontein site. Cave in which australopithecine remains were uncovered has collapsed.

By Ronald Singer

Paleoanthropologists today are methodically uprooting fossil evidence from the African soil and reassembling the evolutionary sequences. Discoveries of the past century have provided a commentary on the origin of the human genus and species, *Homo sapiens*, and many of the so-called missing links have been forged into a likely chain of events.

Mankind was cradled in Africa about one million years ago, some 70 million years after the first primates surged upward in the generalized mammalian genesis that followed the decreasing superiority of Mesozoic reptiles. During that Paleocene period, adverse conditions decimated the giant reptilian genera, and small mammals diversified in geometric progression, either adapting and progressing or becoming extinct along aberrant lines of ecologic experimentation.

During the Lower Oligocene (approximately 40 million years ago), the area that is today called Egypt contained *Parapithecus*, probably the earliest apelike form, as well as *Propliopithecus*, which appears to be a close relative of the ancestral stock of the modern gibbon. Primitive gibbons, long-limbed arboreal apes, are

Makapan Valley was habitat of giant animals and australopithecines about one million years ago. Fossil-bearing breccia from caves awaits processing.

represented in the early Miocene (approximately 25 million years ago) in East Africa by a few genera, of which one advanced form, *Pliopithecus*, spread into Europe and Asia. About 10 million years ago (Pliocene period) it was sufficiently adapted to give rise to the modern gibbons, now confined to Malayan environs.

The Miocene lake bed deposits exposed in the hot, dry gullies on Rusinga Island, near the Kavirondo Gulf of Lake Victoria, have revealed a fairly complete series of fossilized remains of *Proconsul*, an extinct generalized form of ape, of which three widely separated species have been described. They ranged from the size of a small chimpanzee to a large gorilla, and were capable of running and jumping along the ground and along branches. The several dental fragments of the various species of *Dryopithecus* recorded from the Middle and Upper Pliocene deposits of Africa (and India and Europe) reveal considerable variation, so that some resemble the living orang, some the chimpanzee, and others the gorilla, while the cusp pattern of the molars adumbrates those known in the fossil ancestors of *Homo sapiens*. There are many reasons for believing that *Proconsul* or closely allied genera formed an ideal generalized stock that could have given rise to a diversity of evolutionary forms as represented in the Hominidae (extinct and recent forms of man) and the Pongidae (anthropoid apes). In March, 1962, Dr. L. S. B. Leakey announced in the American press the discovery at Fort Ternan in Kenya of specimens stated to be 14 million years old. He claims that this advanced *Proconsul*-like form seems to be midway between the early apes and man. However, these scanty remains at present do no more than confirm the evolutionary potential in a hominid direction of this wide-ranging genus.

The varied and generous African environment provided the lost paradise where the Hominidae separated from the Pongidae, and, during the course of 10 million years, radiating forms moved along a number of evolutionary avenues. Many of these avenues led into a cul-de-sac, but some broadened into the human pathway.

The most significant phase in the study of human origins in the first half of the twentieth century was initiated in 1924 when Raymond A. Dart, then the Professor of Anatomy at the University of the Witwatersrand, recognized the importance of a fossil baboon skull brought to him by a student, Miss Josephine Salmons. The skull derived from a quarry being mined at Taung in Bechuanaland, whence shortly after parcels of pink, bone-bearing breccia—calcified sediment or debris cemented in blocks—were dispatched to Dart. Included therein was the endocranial cast or mold of the interior of the skull, as well as parts of the broken skull into which it fitted. He immediately observed with great excitement that the mold was three times the size of a baboon brain and larger than that of any adult chimpanzee. These remains represented the now-famous juvenile *Australopithecus* ("southern ape") *africanus*, which Dart described in 1925 when he indicated the unique presence of hominid characteristics in an otherwise pongid skull. In the face of an effusive series of critical and

DAYLIGHT STREAMS through collapsed roof of Limeworks Cave. Massive cone of tons of rubble and breccia has yet to be scrutinized by research workers.

unbelieving blasts from experts outside Africa, Dart, with his Australian tenacity, persisted in his initial conclusion. Only eleven years later Dart's insight was irrevocably supported by Robert Broom's recovery of the brain cast and skull of *Plesianthropus* (now *Australopithecus*) *transvaalensis*, fondly termed "Mrs. Ples." Subsequent discoveries stimulated research and discussion throughout the anthropological world—some seeking to disprove, others trying to support the descriptions of the many australopithecine fossils found in South Africa.

Thus it was under a cloud that *Australopithecus*, the first of the primitive hominids, was born. Since 1925 skeletal remains of about 100 individuals have been recovered in the Transvaal at Sterkfontein, Kromdraai, Swartkrans, and Makapan Limeworks. Out of this series have crystallized two genera, *Australopithecus* and *Paranthropus* (which some scientists believe should be merged into the former), two species, and four subspecies.

The most spectacular of these Transvaal sites are the caves at Sterkfontein and in the Makapan Valley. In

CONTINENT OF AFRICA is dotted with major hominid sites from Pleistocene epoch. They range from Algeria in the north to southern tip of South Africa.

caverns, water-eroded or dissolved out of massive hills of dolomite and travertine, the fossilized remains of hundreds of mammals (antelopes, carnivores, rodents, baboons, australopithecines, and many others) are now found cemented by lime into the floors, which have been disturbed by roof falls and by miners' blasting operations. The success of the miners has resulted in innumerable headaches for the paleontologist and geologist.

When scientists were first brought to the Makapan Limeworks caves they found large ramifying blast holes in the side of the hill. Study and analysis later revealed the likely sequence of events prior to economic excavations. At some depth below the surface, probably more than a million years ago, a large cavern was formed by water action on the limestone. Subsequently, through formation and enlargement of cracks in the roof, a large block of dolomite crashed to the floor, partly sealing off the lower part of the cavern and creating another cavern above it. After a further period of time, water action caused much of the roof to collapse onto the floor of the upper cavern, so that the "cave" now had a large communication with the exterior. Naturally, while all of this was going on, percolating water also produced channels deeper down so that lower caverns, which could later communicate with the upper ones, were also being created.

When the sediments were being washed into the cave, large amounts of animal bones were also being deposited on the sloping floor at various places. The four primary questions that arise are:

Were all the bones, which include a small percentage of australopithecine remains, brought in by different carnivores using the cave as a lair during a long period of time?

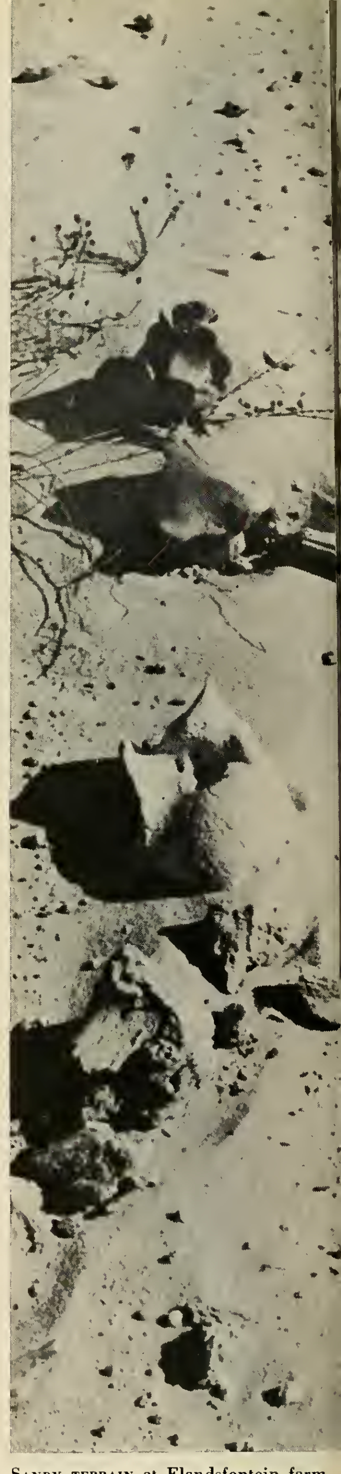
Alternatively, are the fossil remains a midden resulting from australopithecine occupation?

Did australopithecines alternate with carnivores in occupying this vast, ramifying cave?

Is this a midden of a more human animal whose victims included the australopithecines?

Carnivores and rodents have undoubtedly played a part in the cave story, but as yet it cannot be decisively determined, in the absence of any lithic industry at the Makapan Limeworks caves, whether or not the australopithecines occupied them or were only part of the remains of the predatory activities of carnivores or some, as yet undiscovered, more advanced hominid form. At Swartkrans there is suggestion of the latter animal in the few fragmentary remains of *Telanthropus*, which may ultimately prove to represent a pithecanthropine. Professor Dart has continuously maintained that the majority of the bony remains were tools of the australopithecines. However, I am not convinced that any of these bones were *fashioned*, or manufactured, into tools, although it is obvious that any sharp or blunt bony object may have been *utilized* as a tool. In the light of the fact that in South Africa the australopithecine remains have been recovered exclusively from cave deposits, it has been assumed that the ape men were cave dwellers. But if one considers their remains merely as a small part of, and scattered among, the large assemblage of fossilized fauna, then their cave-dwelling nature is purely an assumption, not a conclusion. Actually, the great depth of the caverns, the ape men's lack of knowledge of fire, and the geological evidence of the presence of substantial amounts of subterranean water during the main period of bone deposition work against such an assumption. Furthermore, elsewhere, australopithecine remains have been recovered from open-site deposits, namely Olduvai Gorge, Laetolil, Lake Chad, Jordan Valley, and Java. That such primitive hunters and gatherers of food would have dwelt in caves seems to be an unproved and unlikely behavioral pattern.

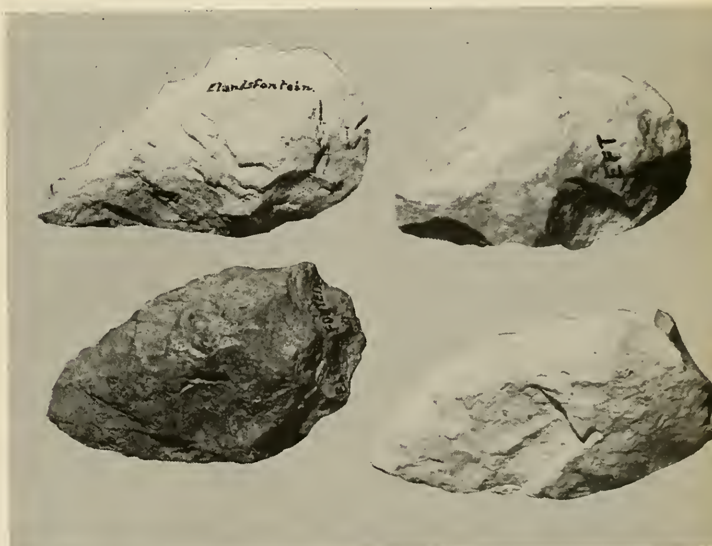
One aspect of the possible habits of australopithecines requires comment. At this very early stage of human history it is probable that the man-apes were living either in troops like modern baboons or in family units like modern gorillas. They lived in an environment dominated by giant mammals, such as now-extinct forms of elephant, hyena, wild pig and wart hog, saber-tooth tiger, rhino, lion, baboon—animals that are best avoided in open combat. So far as the man-apes were concerned, despite powerful, large jaws, their canines lacked a "ripping" quality, and gripping hands were the substitutes for claws. Here, then, was the challenge that required astuteness, experience, and the ability



Sandy terrain at Elandsfontein farm has yielded more than 20,000 fossils

and about 6,000 stone artifacts. Finds include bones of some 35 mammal types.

FOSSIL FRAGMENTS speckle surface of principal site at Elandsfontein. The ferricrete ridge at the left extends in a tortuous path for almost a mile.



HUNDREDS OF HAND AXES like the four above were found at the Elandsfontein site. Saldanha men made them near end of earlier Stone Age in South Africa.

Frontal view of ***Paranthropus robustus*** **skull, discovered at Swartkrans in the Transvaal, shows marked resemblance to** ***Zinjanthropus*** **from the Olduvai Gorge in Tanganyika. Pelvis and vertebral column are more human than apelike.**

to improvise in a difficult situation. Brute strength or speedy legs did not constitute a sufficient defense mechanism, but sharp wits were required, as well as the ability to throw stones, wield sticks, and grapple efficiently. The latter may have involved the creation of the idea of teamwork: while one individual held away an animal's savage jaws, another would respond to the call of alarm and move in with a rock, stave, or heavy bone and bludgeon the beast to death. Survival of the relatively defenseless australopithecines may have depended on the development of an efficient communicating system. Consequently, the dangerous environment, interacting with an innate mechanism and ability to adapt rapidly, created the humanizing tendencies. The freed hands and the enlarging brain were the major devices required to open the evolutionary doors to technological skill and social success. The australopithecine remains represent about 100 individuals, which in general were small animals. The *Australopithecus* female, slender and broad-hipped, weighed roughly 60 pounds, the *Paranthropus* probably half as much again. They were essentially bipedal, and had skulls with a combination of characteristics specific to both pongids and hominids. The hominid jaws, teeth, palatal contour, and jawbone are set against a small pongid cranium resting on a projecting, heavy-jowled face. The pelvis and vertebral column are much more like those of a true man than of any ape.

The Transvaal fossils are real "links" and they demonstrate that the anatomical requirements for the erect posture were present before the brain expanded. It would appear that the concomitant attributes of freed upper limbs, such as the manufacture of tools, the development of a technical tradition, and various "superior" sociological adaptations, were advances associated with an enlarging brain. At the Sterkfontein site there are two distinct phases. The earlier contains abundant *Australopithecus* remains (more than 100 specimens) and this extensive deposit has revealed not a trace of stone artifacts or even foreign stone. Overlying this is a more recent breccia with very scanty *Australopithecus* fossils, but here there are complex stone artifacts, which are less sophisticated than the hand ax culture associated with pithecanthropine remains in North Africa (Ternifine and Sidi Abderahman).

The *Australopithecus* remains at Makapan Limeworks are not associated with any stone tools, so that, in general, it can be stated that about 95 per cent of the remains of this genus are clearly not found with stone implements, while about 5 per cent, at only one site, are associated with an early Chelles-Acheul industry. If the australopithecines manufactured stone implements, and there is no way yet of establishing this, then, by definition,

they were "human," or true men. However, if the australopithecines were not toolmakers, as would seem possible, then there was present at that time a more advanced form whose victims were these ape men and who were the successful competitors for that particular environment. In the evolutionary sense it appears that the presently known australopithecines were "too late" to be the direct ancestors of true man, but they were very close to those ancestors and may constitute an experimental cul-de-sac that radiated from the true hominid ancestral stock.

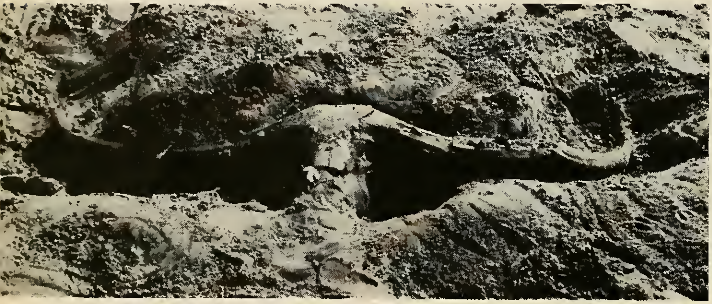
GEOLOGICAL and faunal evidence available at the South African sites indicates that the earlier Sterkfontein deposit is the oldest (Lower Pleistocene), followed by the Makapan Limeworks, and then the later phase of Sterkfontein. Only *Australopithecus* has been recovered from these sites. This sequence is followed by the deposit at Swartkrans and then that at Kromdraai, and these two sites are typified by the occurrence of *Paranthropus*. The pithecanthropine *Telanthropus*, as well as stone tools, make their appearance at the time of the later deposition at Sterkfontein. It is of consequence to recognize that when *Paranthropus* arrived on the evolutionary scene, toolmaking was already an established industry.

Corroborative evidence of the wide distribution of the ape men in Africa was recently uncovered by Mary Leakey in the vast bone repository in the Olduvai Gorge of Tanganyika, where a systematic fossil hunt has been pursued for about 30 years. This australopithecine skull was dubbed "nutcracker man" by Louis Leakey, because of the large, squarish teeth in the upper jaw, and he referred the material to a new genus, *Zinjanthropus*, but it is highly likely that instead it is another species of *Paranthropus*. On the same level (in Bed I) as "Zinj" were also the remains of many mammals and a large number of stone artifacts. In respect to the latter, the questions once again arise: was "Zinj" the manufacturer or was he the victim of those stone bludgeons, manufactured by a more advanced contemporaneous form? In other words was he the killer or the kill? The latter is suggested by such indirect evidence as: (a) the nature of the associated remains does not differ particularly from the thousands of fossil remains, many similarly

RECONSTRUCTED SKULL of Saldanha Man was another Elandsfontein find. It is one of two African variants of Asian and European Neanderthal equivalents.

BROKEN HILL SKULL, found in a cave in Northern Rhodesia, resembles skull of Saldanha Man and is other African find displaying Neanderthaloid traits.

SOLID IRONSTONE forms central core of a sectioned ridge at Elandsfontein. Nature and color of sand deposited on each side of ferricrete differ widely.



EXTINCT GIANT BUFFALO is excavated at Elandsfontein. These bovids, with horns spanning 12 feet, grazed on the veld in herds about 100,000 years ago.

MODERN WART HOG'S TEETH in skull, center, are dwarfed by teeth of giant extinct pig *Mesochoerus lategani*. Old form was as large as young rhinoceros.

grouped, found elsewhere at Olduvai; (b) some of the remains of "Zinj," adult and juvenile, are found scattered in the same area; and (c) a similar scanty distribution of man-ape fragments relative to extensive faunal remains is seen elsewhere, where no stone artifacts have been recovered.

LATE in 1960, a large fragment of the lower jaw and two bones (parietals) of a skull of juvenile age (possibly of one individual) were recovered in Bed I, some feet lower than the "Zinj level" and a short distance away. Some teeth, two clavicles, a portion of a foot, six finger bones, and two ribs were also found. Although Dr. Leakey refers to this site as a "pre-*Zinjanthropus* level," it is not clear what the time lapse between the two levels really was. However, it is probable that it was short. A satisfactory reconstruction of the parietal bones is doubtful, and at this early stage of their study it seems that the jaw and cranial bones belonged to a young australopithecine, possibly a species of *Australopithecus*. The juvenile parietal bones are cracked but the fracture is typical of the result of generalized pressure of the tons of soil and rock resting on it rather than the dramatic "murder" first attributed to it in the newspapers. In any event, "murder" is a term applicable only in relation to laws of human society.

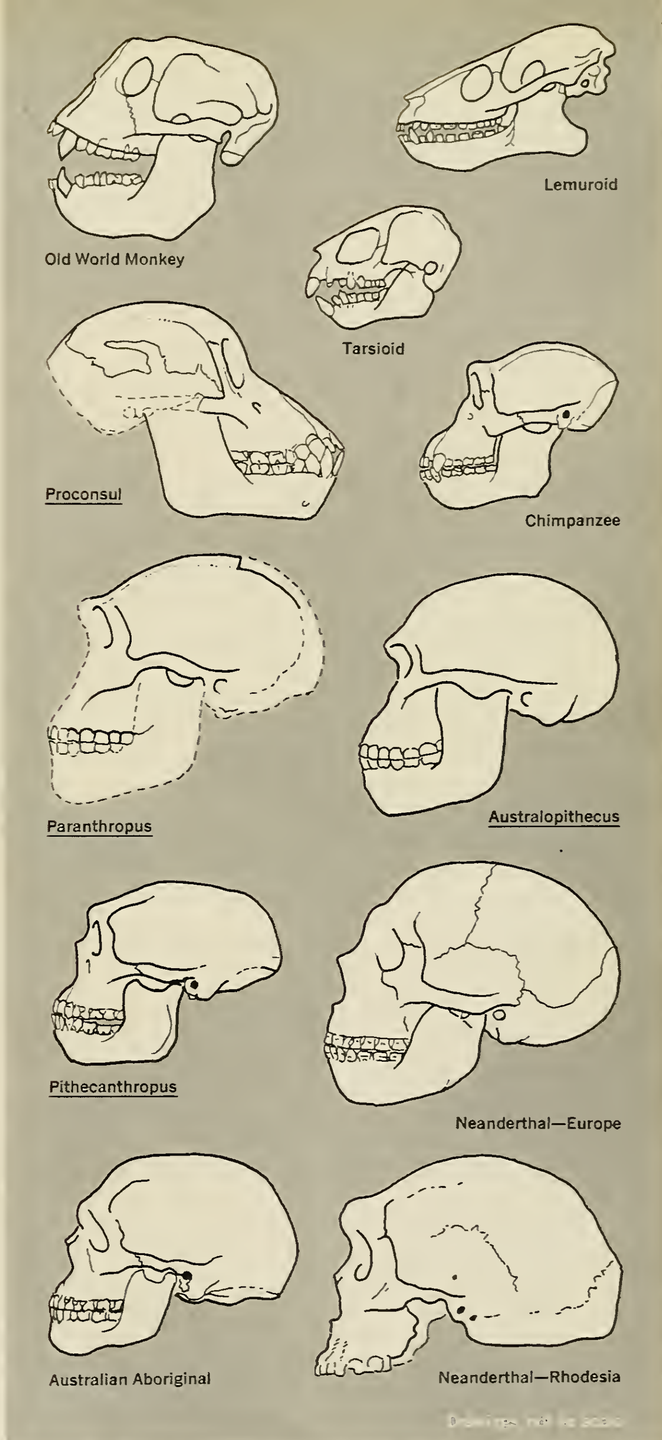
The remarkable little australopithecines were not confined only to the Transvaal and Tanganyika. It should be mentioned that as early as 1939 the latter area provided evidence of the presence of these ape men when some australopithecine-like teeth were discovered by Kohl-Larsen on the Serengeti Plains, not too distant from Olduvai. In faraway Java an australopithecine jaw was recovered just before the Second World War, and during 1961 remains of man-apes were reported both from Lake Chad in North Africa and from northern Israel. Thus we are getting a clearer impression of the widespread nature of the australopithecines, indicating probable migrations over thousands of years extending through the terminal Pliocene and early Pleistocene, which resulted in adaptation to new environments, for better or for worse. We cannot yet assess when and why man-apes ultimately became extinct.

What of the earliest recognized true man in Africa? From the Olduvai

Gorge came news in late 1960 of the discovery of "Chellean Man," named because of associations with relatively advanced implements. He could be considered on the same relative evolutionary footing as *Pithecanthropus* from Java and China, the earliest toolmakers who knew the use of fire. Chellean Man could be considered as an African variant of the genus, with more massive bony supraorbital projections and a number of other minor variations. In North Africa at Ternifine, in Algeria, three human lower jaws were found with many faunal remains and Chelles-Acheul implements. It is considered that these jaws (unhappily placed in a new genus, *Atlanthropus*) also belong to the African *Pithecanthropus* complex. The pithecanthropines, with their distinct hominid posture and with only a few apelike features, constitute essentially a stage of mankind that is ancestral to the later forms, Neanderthal Man and modern *Homo sapiens*. Early pithecanthropines probably overlapped in time and territory with the australopithecines, and may have survived to less than 400,000 years ago.

Although the term Neanderthal Man should be strictly reserved for those stocky, cold-adapted men who occupied the continent of Europe during, at least, the first cold phase of the last glaciation, about 100,000 years ago, one is tempted to interpret similar morphological types living contemporaneously in Africa and Asia as racial variants of the Neanderthals. The immediate post-pithecanthropine phase is at present represented in Africa by two skulls, one from Broken Hill in Northern Rhodesia (Rhodesian Man) and the other 2,000 miles to the south, from Hopefield in South Africa (Saldanha Man). About thirty years ago the fragmentary remains of another beetle-browed individual were discovered approximately 1,000 miles north of Broken Hill near the shores of Lake Eyasi on the Serengeti Plains, not far distant from the Olduvai Gorge. The badly preserved remains were tentatively reconstructed and named *Africanthropus*. Incorrectly placed in a new genus, the *Africanthropus* probably represents a form of *Homo* that is closely related to the Broken Hill and to the Saldanha skulls.

The Broken Hill skull was discovered in the lowest part of what had been a subterranean cave that was



Primates' skulls and dentition show evolutionary changes including facial recession, cranial growth, and lack of big canines from *Australopithecus* on.

An authority on human evolution in Africa. DR. SINGER is an anatomist and physical anthropologist. A co-discoverer of the Saldanha skull, he is now at the University of Chicago.

blasted open by miners in 1921. As in the case of the Limeworks caves, the skull, fossilized faunal remains, and artifacts accumulated at the bottom of a sloping floor. The skull is massive, with thick, projecting brow ridges, surmounted by a flat, sloping forehead. It is so gross-looking that for many years some scientists preferred to consider it as a pathological anomaly—an acromegalic. However, this doubt was dispelled when, in 1953, the author and a field assistant recovered fragments of a skull at Hopefield, that, when reconstructed, was indisputably akin to Rhodesian Man. The new discovery was named Saldanha Man because of the proximity of Hopefield to the historically known Saldanha Bay. The site is on a farm called "Elandsfontein," and consists of a large eroded area (about 2.5 miles by 1.5 miles in size) in the bushy Sandveld. During the ten years of field work I carried out with teams of students and colleagues, more than 20,000 fossils and about 6,000 stone artifacts have been recovered from the surface of the fossiliferous floors that lie between the 40-foot-high sand dunes of Elandsfontein farm.

This remarkable, fossil-strewn site must be seen to be believed. Almost every foot of the surface between the dunes reveals a recognizable fossilized bone as well as hundreds of minute chips of fragmented bone. From this site more than 35 mammalian genera and many more species have already been diagnosed. These animals represent a mixture of the grassland and bushveld faunas, a situation seen today around the Etosha Pan in South West Africa, where arid conditions have forced these two different types of fauna to congregate around the only constant drinking place in a vast region. The Hopefield fauna, 20 per cent of which are extinct forms, occupied the site during the period extending from the tail end of the Middle Pleistocene to the early part of the Upper Pleistocene of southern Africa—that is, about 200,000 to about 100,000 years ago. The breakdown of the faunal forms, coupled with pollen analysis, leads to a picture of the landscape at that time—open savanna country merging with distant scrub and bushveld, and forested regions scattered toward the mountains on the horizon.

About 15 miles from Hopefield is another fossil site at Langebaanweg. Here, too, commercial interests have unearthed a wealth of fossils—the upper layers overlap the Hopefield period, while the lower, phosphate-bearing strata are yielding fossils of a Lower and Middle Pleistocene epoch: three-toed zebrines, archaic elephants, and short-necked giraffids. Sea invasion of the extensive site (about six square miles) is indicated by the presence of numerous sharks' teeth scattered among some of the mammalian remains. If a hominid should be discovered here, it may well prove to be another "key" form in the intricate evolutionary mosaic.

Thus Saldanha and Rhodesian Man, who, although found 2,000 miles apart, are alike as brother and sister (in the evolutionary sense), represent the African variation of the Neanderthal equivalent of Europe and of Asia. Interestingly, the African and Asian forms are more like each other than either is to the European form. We can picture that distant period as having three major racial variants of mankind on three major continents, which, though separated by distance, came into contact with each other by intercontinental migrations, sharing their cultures and mixing their stocks so as to blend the later, more modern forms of mankind.

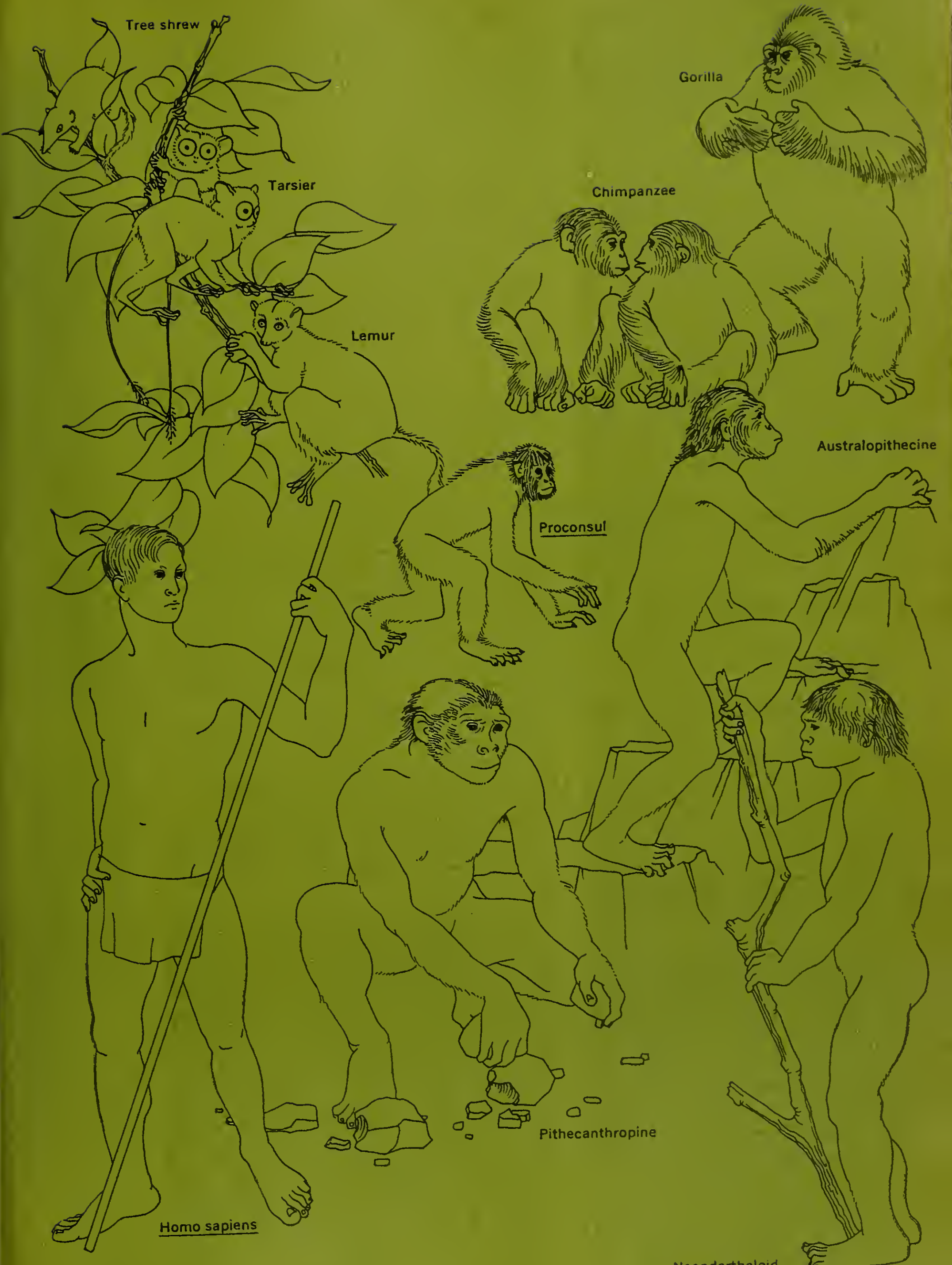
Scattered throughout southern Africa are dozens of other sites revealing the fossilized representatives of the subsequent, more modern types, essentially the ancestral stocks of the Bushman, Hottentot, and Negro as physical entities. Many of the skeletal remains display blending of these racial types, now the one accentuated, then another, thereby indicating that about 30,000 or fewer years ago these three racial groups may have been separating from a stock common to all. Thereafter, by drifting apart into different environments, they developed the physical and cultural characteristics that, in the extreme, are widely separated. Recent serological studies of these three living races indicate the remarkable similarity between the Hottentot and Bushman gene frequencies and those of the characteristic genes of the Negroids.

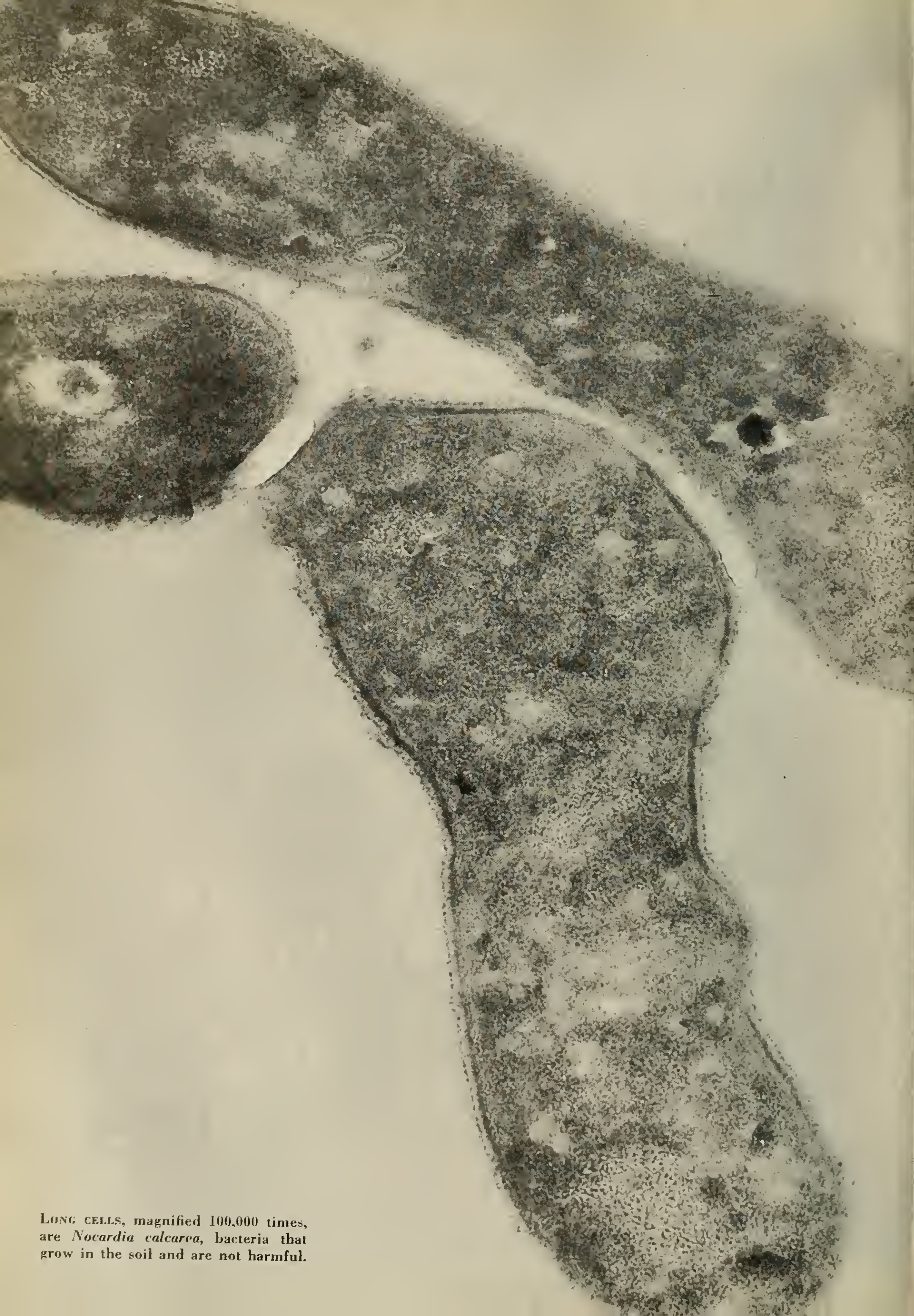
It requires a monograph, not an article, to do justice to the phenomenal wealth of evolutionary material already removed from Africa's soil. An outline of the biological trend in one of the indigenous populations—the Bushmen—was given in NATURAL HISTORY, February, 1961, by Professor Tobias. Untouched in the present article is the evolution of their cultures—the stone artifacts, paintings, engravings, or pottery. A glimpse of the tremendous source material available can be given merely by stating that in 1941 more than 2,000 sites displaying cave art or rock engravings had been recorded in South Africa, and since then hundreds of new sites have been noted. Yet despite this mass of information we know very little of the painters of the various styles, of the correlation between cultures in the floors of the caves and the art on their walls, of the composition of the paint itself, and how it has endured untold centuries on rough, rocky walls.

What were the racial affinities between the groups of skeletons recovered in South, East, and North Africa, say, 25 to 50 thousand years ago? When were the crucial periods of contact between Africa, the Middle East, and beyond? In which directions were migrations taking place at certain periods? Who manufactured the beautiful giant hand axes and other stone implements found at Olorgesailie in East Africa and at Stellenbosch in South Africa? These and a dozen more questions face the paleoanthropologist and archeologist of the present and of the future. Africa's rich biological heritage is a challenge to the scientist, and despite all the discoveries already made, it is, relatively speaking, virgin territory for future explorers in both the biological and the earth sciences.

Great discoveries have uncovered the emergence of man in Africa. The synthesis of the knowledge available and the solution to the many mysteries surrounding our ancestral forms await us. It is by no means an idle cliché to repeat the ancient Greek saying, attributed to Aristotle, that Africa is always producing some novelty.

EVOLUTION PROCESS that led to *Homo sapiens* took place during 70 million years. Some living and extinct forms in evolution of primates are at right.


Tree shrew
Gorilla
Chimpanzee
Tarsier
Lemur
Australopithecine
Proconsul
Pithecanthropine
Homo sapiens
Neanderthaloid



LONG CELLS, magnified 100,000 times, are *Nocardia calcarea*, bacteria that grow in the soil and are not harmful.

World Within A World

Bacteria are scrutinized at high power

By Audrey M. Glauert

Author mounts a specimen that will be studied under the electron microscope.

Bacteria are both the enemy and the friend of man, and as such they have been of absorbing interest since they were first discovered almost 300 years ago. The largest bacteria are less than one-thousandth of an inch long, so their discovery awaited the invention of the microscope. In 1676 the Dutch microscopist Antony van Leeuwenhoek examined a drop of water in which he had placed whole peppers and saw "little animals which . . . were incredibly small; nay, so small, in my sight, that I judged that even if 100 of these very wee animals lay stretched out one against another, they could not reach to the length of a grain of coarse sand; and if this be true, then ten hundred thousand of these living creatures could scarce equal the bulk of a coarse sand-grain."

Van Leeuwenhoek was also amazed by their large numbers. ". . . the whole water seemed to be alive with these multifarious animalcules. This was for me, among all the marvels that I have discovered in nature, the most marvelous of all; and I must say, for my part, that no more pleasant sight has ever yet come before my eye than these many thousands of living creatures, seen all alive in a little drop of water, moving among one another, each several creature having its own proper motion: and even if I said that there were a hundred thousand animalcules in one small drop of water which I took from the surface, I should not err."

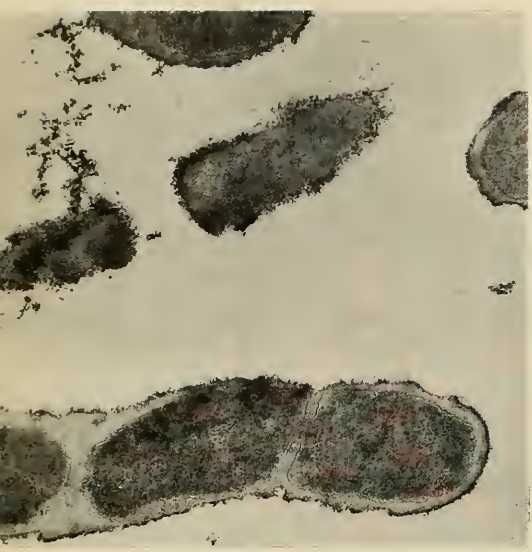
Great advances in the study of the "small animals" were made by Louis Pasteur. He devised methods for growing the microorganisms on artificial media, and was able to encourage some of the bacteria to grow at the expense of others by varying the chemical constituents of the medium. In this way he obtained "pure" cultures and could study the properties of each different bacterium more closely. More recently, the invention of the phase-contrast microscope has made it possible to watch living bacteria as they grow and divide, and today we can begin to write their life-histories.

Bacteria are found everywhere; in the ground, where they play an essential part in the decay of humus and the consequent enrichment of the soil as food for plants; in the intestines of animals, where they usually do no harm; in water and in the air. Only a few of the many hundreds of different bacteria are harmful and cause diseases in plants or animals; the majority are beneficial and essential in agriculture, brewing, and the manufacture of medicines. In spite of their varied behavior, bacteria all look very much alike and can be classified into a few basic types.

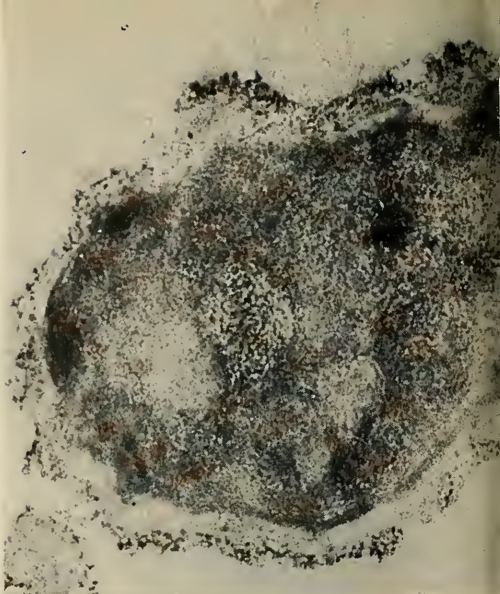
The simplest are the spherical bacteria, or cocci, which usually have diameters of about two ten-thousandths of an inch. They multiply by growing in size and splitting at their equators into two equal parts. These two parts, or daughter cells, separate from each other, and each grows until it is the same size as the original bacterium. This process of division continues indefinitely so long as sufficient food is available, allowing the formation of large groups, or colonies. Sometimes, the cocci do not separate completely during division, and rafts of cells are then seen. Some of the streptococci, staphylococci, and pneumococci are pathogenic to man.

The rod-shaped bacteria, or bacilli, also have a simple life-history. A single rod elongates and divides in two. These, in turn, grow and divide, so that eventually a colony of many rods is formed, with each rod similar to all the others. A slightly more complex method of division is found among the mycobacteria, such as the tubercle bacillus, which sometimes grow into long filaments. These divide simultaneously at a number of places, forming a row of rod-shaped bacteria. The mycobacteria can also grow by putting out side branches called mycelia, which remain attached to the main stem for some time.

The most complex life-histories are found among the actinomycetes. These never grow as simple rods, and always form a permanent mycelium. The life cycle of an actinomycete, such as a streptomycete, starts with a single spherical spore. If placed on a plate of new medium, the spore germinates and two more thin germ tubes emerge. These elongate and widen, while at the same time buds appear and grow out to form side branches. This growing and branching continues until a large system of interconnected hyphae—threadlike filaments—is formed and is visible to the naked eye. When the food supply begins to run out, some of the hyphae grow upward into the air and form an aerial mycelium. Eventually the hyphae subdivide into rows of rod-shaped units that look rather like a string of sausages. The units



AGENTS OF FERMENTATION are *Lactobacilli*, which grow in milk and help to turn it sour. Magnification is 40,000 times.



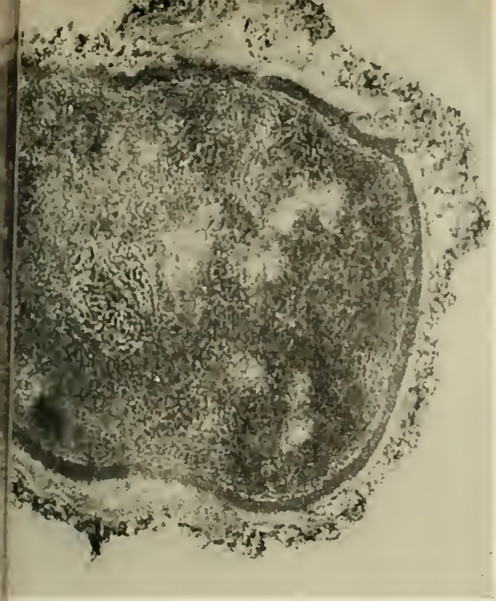
THICK EXTRA LAYER of secreted mucous material around the cell wall of this *Corynebacterium fascians* is known as a

ROD-SHAPED BACTERIA that cause the black arm disease in cotton plants are *Xanthomonas malvacearum*, and can be seen here magnified 200,000 times.

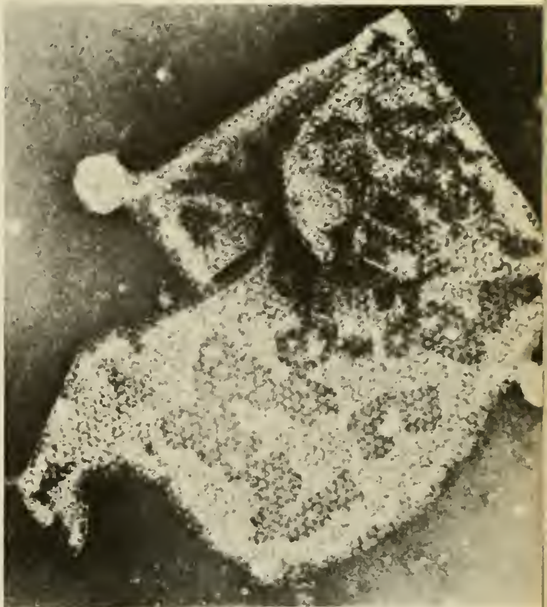
separate from one another, each becoming a spherical spore. If a spore is transferred to a new plate of fresh medium the whole life cycle begins again. The actinomycetes are the chief producers of antibiotics, such as streptomycin, aureomycin, and terramycin—substances that kill other bacteria and can therefore combat diseases caused by bacterial infections.

THE history of the study of bacteria is a striking illustration of the way in which scientific advances are sometimes dependent upon the invention of instruments. The light microscope, in the hands of Antony van Leeuwenhoek, revealed the world of microorganisms and made it possible to observe the behavior of bacteria; today the electron microscope shows a world within that world, permitting examination of finer details.

When bacteria were first observed in the electron microscope, which is much more powerful than its predecessors, the results were somewhat disappointing, as a beam of electrons can penetrate through only a small thickness of any material. If the object is too thick the electrons are scattered and absorbed and nothing is seen. To get a clear picture, a specimen should not be more than 500 Angström units (about two-millionths of an inch) thick. One way to study an object even



capsule. Layer may be most toxic part of a bacterium and may damage and ultimately destroy surrounding host cells.



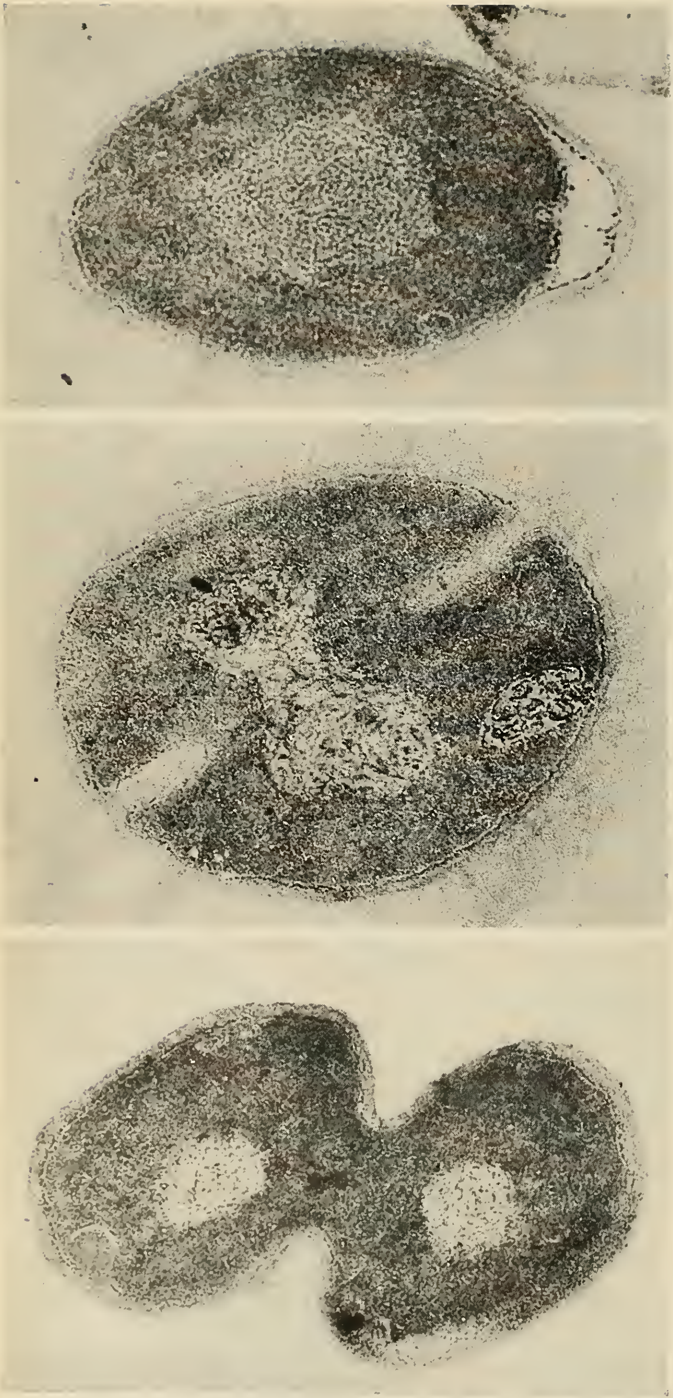
as large as a tiny bacterium is to cut it into very thin sections. Examination of a row of adjacent, or serial, sections made through the same bacterium allows the deduction of a three-dimensional picture of the structure.

Each bacterium is an independent organism and carries within it full potentialities for its reproduction, growth, and protection. Its main armor is its rigid cell wall, which helps the organism to withstand pressures and maintain its shape. Some bacteria have an extra layer of material, known as the capsule, outside the cell wall. This consists of secreted, pliable, mucous material that adheres to the wall as the bacterium moves about and grows. Sometimes the capsule is the most toxic part of the organism and does the most damage to host cells that engulf it. For example, pneumonia is caused only by those particular pneumococci that have capsules.

The cell walls of bacteria are composed of different materials from those comprising the rest of the cell. The materials are packed together to form a rigid structure that determines the bacterium's shape. Cell walls of some bacteria can be removed with an enzyme called lysozyme, leaving a naked protoplast that has no rigidity and that quickly assumes a spherical shape, even though the original bacterium may have been rod-shaped.

NUCLEAR REGIONS of colon bacilli are seen as light areas in dense cytoplasm.

DARK BACKGROUND STAIN shows pattern in the cell wall fragment of a coccus.



SPHERICAL BACTERIUM division, as seen in sequence, begins with resting cell *top;* nuclear material then separates, *center;* two cocci are formed, *bottom.*

Since 1950, DR. GLAUERT has been studying the structure of bacteria at Strangeways Research Laboratory, Cambridge, England, as head of the Department of Electron Microscopy.

Little is yet known about the finer structures of the cell walls. Electron microscope pictures of bacteria sections show that the wall has a number of different layers, but the material components and the manner in which they confer rigidity is not yet exactly known. More of the wall structure can be seen in a surface view than in a thin section, so the wall is separated from the rest of the bacterium for microscopic examination.

ONE technique, known as "negative staining," was developed by Mr. R.W. Horne and Dr. S. Brenner of Cambridge, England, and has been used for the study of large cocci. With this method, the bacteria are first disrupted mechanically by high-frequency sound waves, and the fragments of the walls are mixed with a solution of phosphotungstic acid (PTA). A drop of this mixture is allowed to dry, and when it is examined in the electron microscope the pieces of wall are seen lying in a dense pool of PTA. Any structure that is present on the surface of the wall is shown up in relief against a dark background. This technique has revealed that the walls of some of the large cocci have exceedingly complex patterns with hexagonal symmetry.

Under the cell wall lie the nucleus and cytoplasm. As in all living organisms, the nuclear region of a bacterium contains the genetic material that determines the cell's behavior and future development. In more complicated cells this hereditary material is contained in organized chromosomes, but in bacteria it appears in a simpler form as a mass of fine fibrils within a light area in the cell's center. These fibrils are no more than 50 Angström units in diameter, and consist mainly of deoxyribonucleic acid (DNA), a substance found in the chromosomes of all cells (NATURAL HISTORY, December, 1960). DNA carries the genetic information of the bacterium; it has been shown that DNA extracted from one bacterium and introduced into another can alter the manner of growth of the recipient cell. When a bacterium divides, the fibrillar nuclear material also divides, and part of it goes into

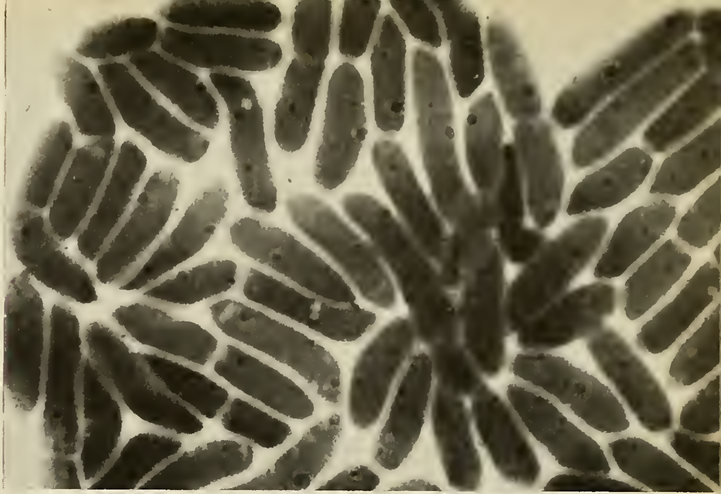
each daughter cell. During division, the individual fibrils are sometimes seen lying parallel to one another in an organized pattern, and it is presumed that some are moving to one daughter cell and some to the other.

The nuclear material is surrounded by dense cytoplasm that consists mainly of ribonucleoprotein in the form of numerous, very small granules, which are often so tightly packed that the individual units cannot be seen. The cytoplasm is bounded by a thin, cytoplasmic membrane that lies just inside the cell wall. In some bacteria the cytoplasm contains membranous bodies that are often connected with the membrane. It is presumed that they arise as membranous proliferations, although they may later become detached and lie freely in the cytoplasm. Larger granules of various kinds are also seen in the cytoplasm, and are usually storage sites for substances such as fats and carbohydrates. A striking feature of the cytoplasm of the mycobacteria, corynebacteria, and streptomycetes are the volutin granules, which at some stages of their growth are so dense that they appear completely black in the electron microscope pictures.

Many bacteria move about if they are put into a liquid, some of them fairly rapidly and in a definite manner—"each having its own proper motion," as van Leeuwenhoek observed. The electron microscope reveals that long, wavy filaments, or flagella, are attached to them, and if they are taken off, the bacteria can no longer move in an organized manner.

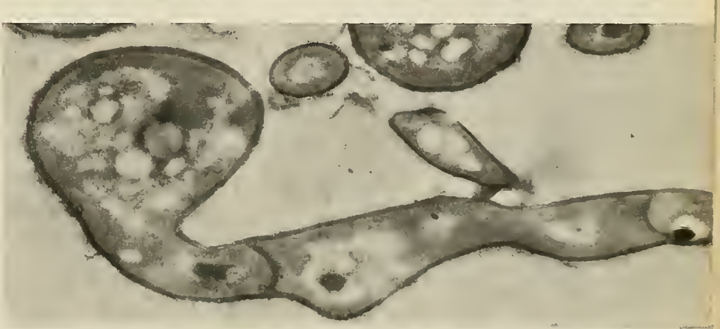
It is still not known exactly how the flagella help the bacteria move, but it is certain they act as a kind of rudder, if nothing else. The flagella are very thin, with diameters of about 150 Angström units, and are attached to the main body of the cytoplasm rather than to the cell wall. In some bacteria the flagella are apparently fastened to a special structure known as a basal granule. Each bacterium may have one flagellum or many, which may be attached at one end only, at both ends, or over the entire surface.

Some bacteria grow as parasites within the cells of other organisms, and those known as "pathogenic" destroy their hosts in the process. There are only a few known examples of genuine symbiosis, in which bacteria and host appear to live together with-

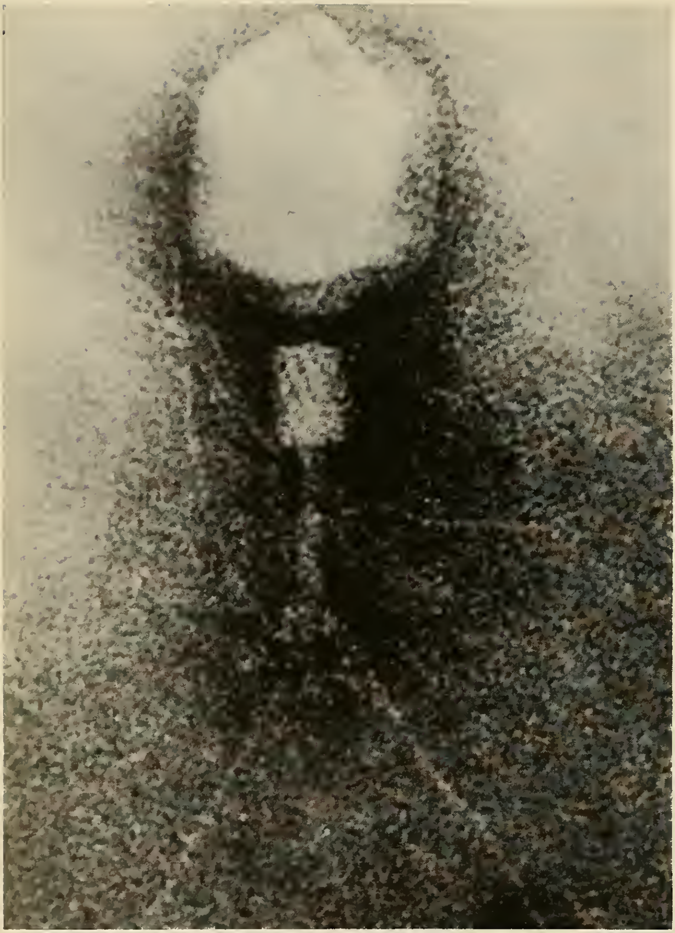


COLONY OF BACILLI is formed with the repeated elongation and division of the rod-shaped bacteria. Dark spots in the cytoplasm are dense volutin granules.

THREE germinating, unsectioned spores of *Streptomyces coelicolor* are seen in silhouette when photographed directly with a magnification of 20,000 times.



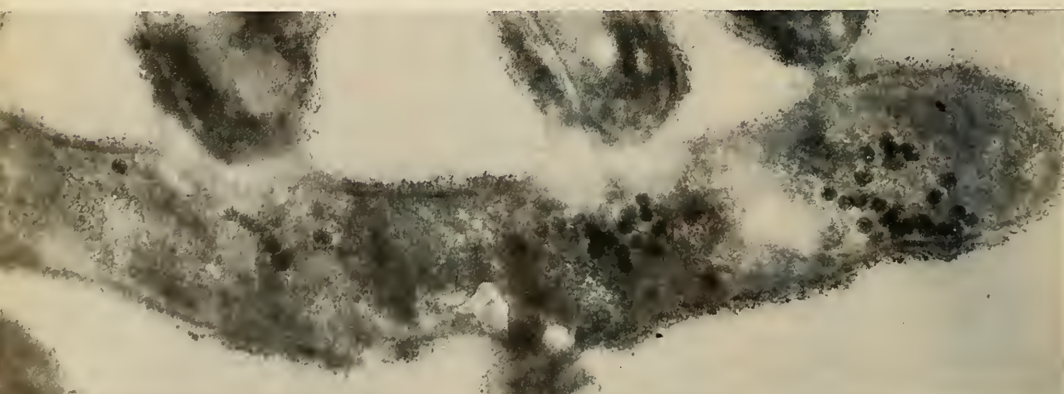
THIN SECTION from a similar spore at 50,000 magnification shows detail of interior not seen in whole bacterium, which the electrons cannot penetrate.



BACTERIOPHAGE, the virus that destroys bacteria, is seen with the characteristic large head, which carries DNA, and the thin tail, at 560,000 magnification.

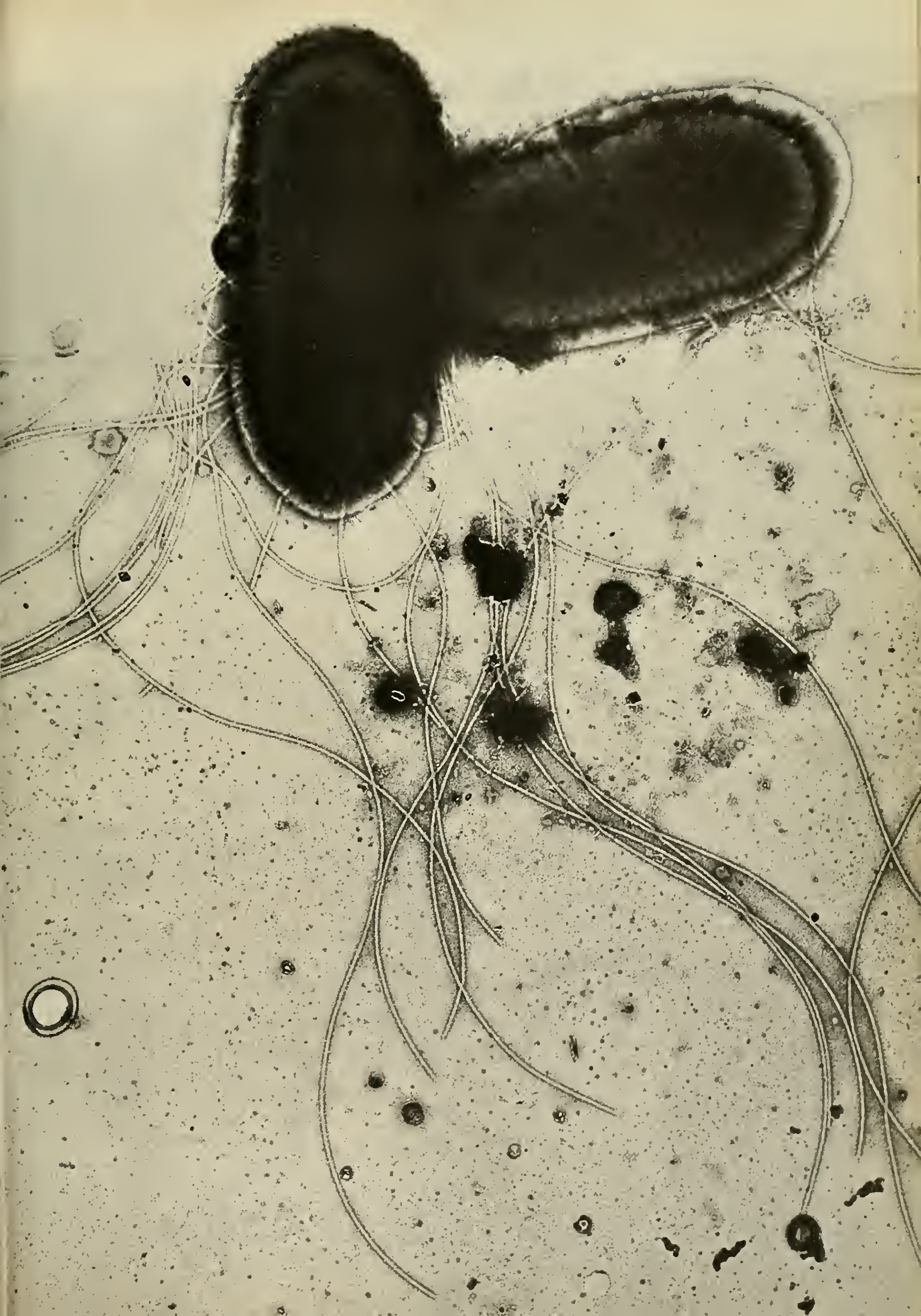
out harming each other. Bacteria themselves are susceptible to infection, and are attacked by a special kind of virus, a bacteriophage. These have a characteristic "tadpole" shape, with a large head and a thin tail. The head contains infectious DNA, which is different from the bacterial DNA, and is able to take over control of the bacterial cell, ultimately destroying it. The bacteriophage attaches itself by the end of its tail to the outside of the bacterium's cell wall and then injects DNA from its head down through the tail, which is hollow, and into the bacterial cell. When the DNA enters the bacterium, it disrupts the cell's normal working and causes it to cooperate in the manufacture of many more bacteriophages. If thin sections are studied at this stage, the viruses can be seen inside the bacterium. Eventually the bacterial cell wall breaks and thousands of new bacteriophages are released. These spread further infection, which can soon destroy a whole colony of bacteria.

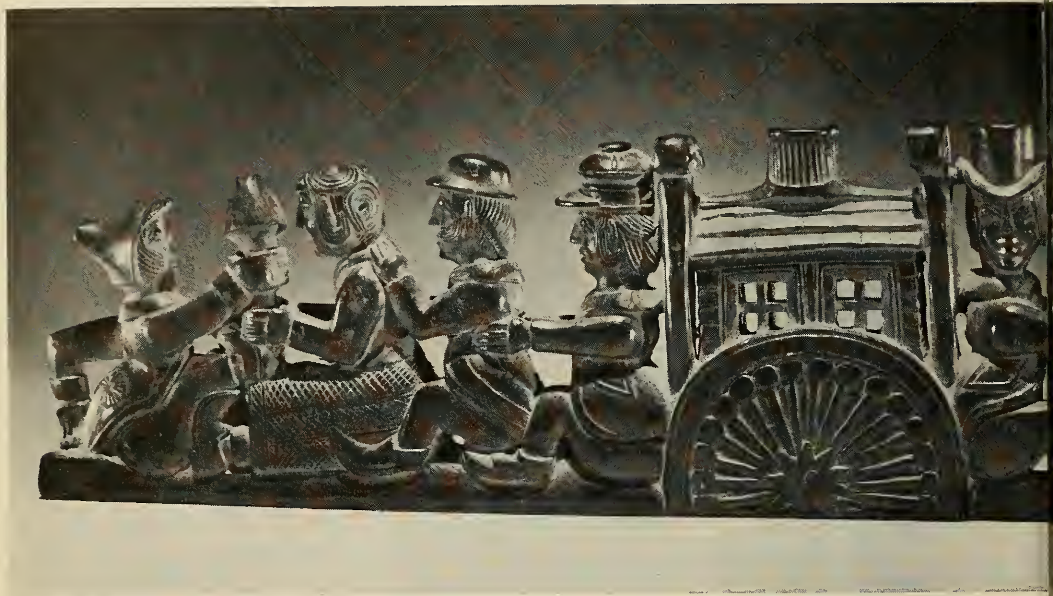
As we have seen, the electron microscope has already revealed a wealth of intricate structures within the bacterial cell, but there is still much to be answered. What are the functions of the various structures? Which are concerned with the manufacture of antibiotics? How are the complex cell walls made and enlarged during growth? Many of these questions can only be answered through a co-operation of biochemists, bacteriologists, and electron microscopists, and through their collaborations new knowledge of "small animals" will emerge.



INFECTED BACTERIUM is disintegrating under an attack by bacteriophages, whose heads appear as black dots in cell.

LONG FLAGELLA attached to surface of motile *Acetobacter* are outlined, *right*, by a dark stain of phosphotungstate.





Kwawhlhal Carvings From Skidegate

AN UNTRADITIONAL HAIDA ART

By FREDERICK J. DOCKSTADER Photographs by LEE BOLTIN

ALTHOUGH they are relatively familiar to most museum visitors, little is actually known—and much less written—concerning the black stone carvings of the Indians of Queen Charlotte Islands, British Columbia.

These delightful statuettes and figurines, usually called "slate carvings," are actually made of argillite, a carbonaceous shale that is relatively soft when first quarried, and which hardens when exposed to the air. Known to the Indians as *kwawhlhal,* the stone is found only in one limited area at the base of Slatechuck Mountain on Graham Island, about eight miles from Skidegate. By government fiat, only the inhabitants of this region are permitted to quarry and work the deposit.

The art belongs to men of the Haida tribe, now some 1,250 Indians living on the Queen Charlotte Islands and the neighboring Alaskan mainland. They speak a language distantly related to the Tlingit of British Columbia; their art work is also similar to that of the Tlingit, and these two peoples are regarded as among the finest Indian sculptors of the Northwest Coast region.

Argillite is found in varying shades

Combination of scrimshaw and a more indigenous work is seen in this early carving of a paddle-wheel steamboat.

Detail of twenty-inch-tall totem pole shows monumental quality Haida achieved in this relatively small art form.

of gray and black when mined; some brown shale is also occasionally seen. The stone is quarried and taken to the sculptor's home; there it slowly dries, and the carving is undertaken with iron or steel tools. After the finished cutting is done, the object is rubbed down and polished with a cloth filled with a mixture of petrolatum and graphite. This technique effectively brings out the beautiful, jet-black sheen of the surface.

This is not a traditional native art; it developed out of the early years of Indian-White contacts. Sailors brought examples of their carving, called scrim-

Sea dog, with the body of a bird, was found at Skidegate in about 1895. Originally, it was intended to be used as the finial of a staff.

Charm, showing whale heads, was drilled for suspension from a shaman's costume. Staff finial of eagle, *below,* was most probably made after 1890.

DR. DOCKSTADER, the author of *Indian Art in America,* recently published by the New York Graphic Society, is also Director of the Museum of the American Indian.

shaw, into port with them; Haida men who went to sea with the whaling vessels learned the techniques of scrimshaw carving, and began to make various objects in wood. As the demand increased, some Haida artists turned to their native stone, and an industry came into being. We do not know when the argillite art actually began; the earliest dated pieces known were collected about 1820. If the argillite pipe collected by William Clark (page 35) was acquired during his trip with Meriwether Lewis, the date would be pushed back to 1804-1806; it may be, however, that it was collected later during his service as Superintendent of Indian Affairs, about 1820.

The small, shiny *objets d'art* quickly caught on, and by 1850 they were known throughout the world. Journals left us by travelers of the period attest to the large numbers of "black slate carvings" offered for sale. The "Golden Age" of this art was between 1840-1880. By 1880, attention turned to quantity, and quality began to suffer; technical skill began to run away with the carvers, and about the same time miniature totem poles became particularly popular and were made literally by the hundreds.

SUPPLEMENTAL ornamentation was achieved by means of ivory, bone, or abalone shell inlays; sometimes (as in the cover illustration) the finished carving was further enhanced by rubbing pigment into the lines, not only to emphasize the carving, but also to relieve the monochrome black of the object.

It should be pointed out that this was an impractical art form, in a sense. The objects were created solely for visual pleasure. The pipes were not smoked; the dishes were not used; the boxes were not practical containers. They were strictly commercial products, made to be sold as decorations.

The great variety of forms created by these artists is well demonstrated by the specimens selected and photographed by Lee Boltin. In this respect, they duplicate the "traditional art" of the Haida, for most of the design motifs carved following the introduction of argillite work can be found in their other art forms.

In the elaborately interwoven miniature totem pole designs, which are the most familiar, the remarkable ability of the Indian artist to reduce proportions can be seen. Although faithful to the full-size prototype, the detail on page 31 illustrates the monumental character that is communicated by the miniature.

In most studies of aboriginal art expressions, the names of individual masters are lost to us. These Haida pieces present one of the very few examples in which a considerable degree of information is avail-

Dramatic rendition of legendary Bear Mother who wed a grizzly is particularly interesting by virtue of the Russian-style cap and cloak.

Typical of Haida work is miniature totem pole, collected in 1885. On top of the bird at the pole's base is the usual motif of interwoven animals.

Slightly earlier totem pole shows bear, at bottom, seated on frog helmet. Woman wearing a labret is surmounted by mythical sea monster.

Pipe, *above*, shows man seated in whale canoe holding a seal he has captured. Face is made of bone, and eyes are made of inlaid abalone shell.

William Clark, the explorer, gave this pipe to artist George Catlin before 1832. His painting of piece aids in checking the art's chronology.

Odd "Noah's Ark," *above,* includes man in canoe with various animals common to the area— a subject frequently used by the Haida artists.

Detail of similar canoe by same artist shows exaggeration he has given to certain parts of the body in order to establish emphasis.

able about the artists themselves. The primary student of argillite carving, Dr. Marius Barbeau, has recorded the life careers of many of the most active sculptors. Since the life span of many of these men covered almost the entire period of argillite work, we have a fairly good record at hand. Familiar names associated with the art are Charles Edensaw, William Dixon, Charlie Gladstone, Isaac Chapman, and others.

TRIBAL legends, history, and events are recorded in these little statuettes; some are visual records of actual happenings; others are traditional accounts that the carver enjoyed relating. The derived origins of the art, together with its perpetuation by outside promotion and inspiration, is quite parallel to the work of the Hudson Bay and Baffin Island Eskimo steatite carvers (NATURAL HISTORY, February, 1960). Here again, outside influence accounted for the "invention" of the art form, and for many of its designs; from there, the indigene took over and developed designs in his own fashion.

Standing figure with ivory inlay shows shaman wearing painted kilt, nose ornament, bone necklace, and holding his rattle and other accessories.

On one side of ear ornaments is an animal spread out in flat design; on the reverse side is seen a hawk design. These were made before 1850.

Few large collections of argillite carvings exist today. The stone breaks easily, and it is not unusual to find a fine specimen from which parts of the original design are missing; vulnerable protuberances, such as heads, hands, birds' beaks, and so on, snap off and are lost. Furthermore, in former years, the commercial background of the art gave rise to a false snobbism, and many collectors and curators had little interest in it. Only recently has recognition been extended to this phase of Haida work, putting it in its proper perspective as a minor art expression that reflects many of the finest technical skills of the Northwest Coast artist. If further proof of recognition is needed, it is ironic to note that imitation, that sincerest form of flattery, has also begun to appear in the manufacture by non-Indians of cast replicas, which are often passed off as "the real thing."

While many argillite carvings admittedly include some of the less happy aspects of derivation, commercialism, and pressure production, these small creations still have an exciting quality all of their own.

Shallow dish with bone inlay reveals some relationships to Russian and European prototypes, and to nineteenth-century cabinetmakers' chip-carving.

Particularly fine carving shows Haida family.
Woman at left wears labret; her husband
sits in front of a carved box; their child is at right.

Vision in Frogs

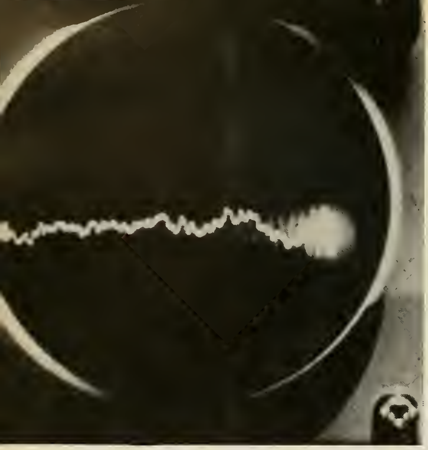
Study of leopard frog's sight sheds light on image formation

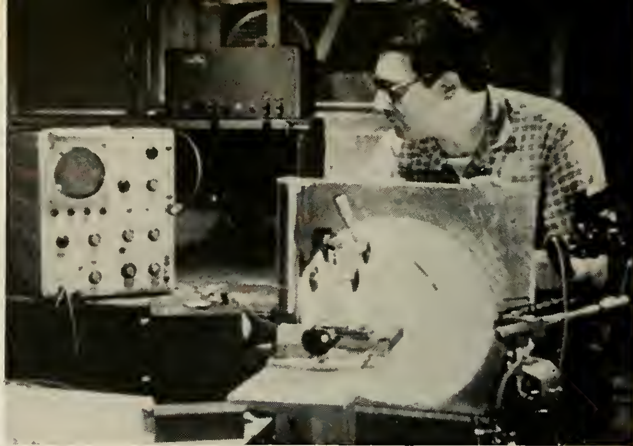
By John Pfeiffer

A frog on a log, staring directly ahead through cold, expressionless, and bulging eyes, appears as silent and unmoving as a stone. But from a more basic viewpoint it is engaged in an activity that is essential for the survival of any predator. It is waiting—and not impassively. That frog is a self-releasing, living catapult in a state of tension. Its attention is in sharp and intensive focus. Nothing in the world exists but the signs of its prey and its enemies. Its sole purpose as it sits is to eat and to avoid being eaten, and it is wonderfully designed to fulfill that purpose. At the right moment, the frog springs into action. Its jump requires about three-tenths of a second from take-off to target, and represents an impressive display of precisely timed muscular co-ordination.

Readers of this magazine are familiar with the biomechanics of the jump ("A Bullfrog and Its Prey," Natural History, February, 1961). This article is concerned with the frog's neurophysiology, with the brain that triggers the jump on the basis of information flowing in from the environment. Recent research, involving painstaking experiments and the use of highly refined techniques, has yielded fresh insights into the frog's nervous system. Furthermore, the new findings have far-reaching implications. They point the way to a deepening understanding of all brains, including man's, and have greatly interested scientists developing more "intelligent" machines.

The work is under way in the Research Laboratory of Electronics at the Massachusetts Institute of Technology. Jerome Lettvin, Humberto Maturana, Warren McCulloch, and Walter Pitts have devised a new method of recording signals from single nerve cells and fibers in the brains of leopard frogs, *Rana pipiens*. They are concentrating on a study of visual mechanisms, because frogs receive most of their information about the outside world through their eyes. In one type of experiment, microelectrodes—probes consisting of fine wires with tips less than a five-thousandth of an inch in diameter—are inserted into the optic nerve, the bundle of fibers that picks up signals from light-sensitive cells in the retina, or viewing screen of the eyes, and transmits the signals to the brain.





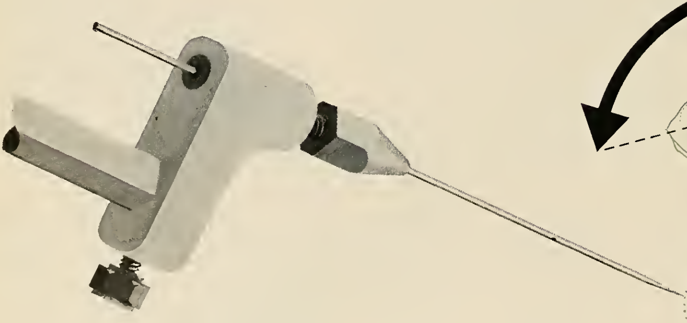
STRAIGHT-EDGED FORM on screen elicits no response from fiber of leopard frog's optic nerve when form is fixed in fiber's visual field. Lack of deflection in the oscilloscope line, *left*, means the microelectrode detected no impulse.

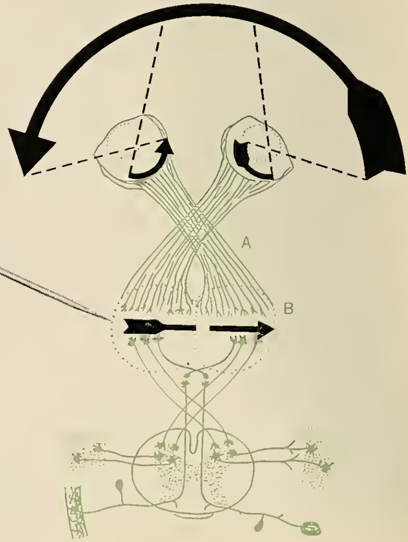
THE microelectrodes detect electrical activity from individual optic nerve fibers as frogs watch various forms moving on a curved aluminum sheet. The signals may be observed as spikes of light on the screen of a cathode-ray oscilloscope, or as specific sounds from a loud-speaker. The nature of the signals—characteristic "spike patterns"— indicates that a microelectrode is actually recording primarily from a single fiber. Improper placement tends to give rise to jumbled static, which buries the signal of any one fiber in a background of similar signals from many other fibers. In the latter case, the wire is adjusted until a "clearly tuned" signal appears.

Before presenting results, it should be pointed out that the experiments are far easier to describe than to carry out. The vast amount of work required to develop effective techniques, or the value of the techniques once they have been developed, is rarely emphasized sufficiently in discussions of scientific advances. Much current research depends to a very large extent on supersensitive devices and instruments that have been refined only after years of effort. The microelectrode is an excellent example.

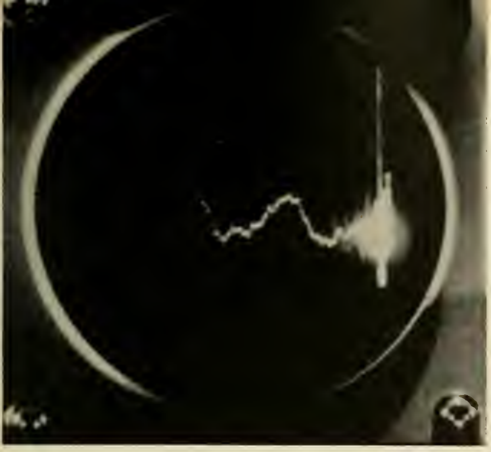
In 1936 E. A. Adrian, the English Nobel Prize winner at Cambridge University, began to record signals from single nerve fibers. The first microelecti odes were introduced about a decade later. Although the devices have been improved since then, only recently have they furnished reliable data on a large scale. A major problem to be solved has been the obtaining of pure, undistorted signals—a problem relating to that which confronts astronomers attempting to measure the extremely faint radio signals of one star among many stars and galaxies, all of which are emitting competing signals.

The faint message of a nerve cell, too, may be buried in a cacophony of signals coming from other nerve cells, from muscle and other tissues, and from the electronic gear itself, including the amplifiers of the recording equipment. Various theoretical considerations suggested that one helpful step would be to electroplate to the tip of the





MICROELECTRODE, held in chuck of a micromanipulator, is aimed at tectum (B), visual brain center of frog. Fibers of optic nerve (A) are braided and cross over, but in the tectum they assume relative positions they had in retinas.



PRONOUNCED RESPONSE is registered when small black disk is moved into the field of a bug perceiver fiber. Convexity and small size of object evoking reaction are significant, since both are attributes of insects on which frogs feed.

microelectrode a tiny ball of fused platinum particles. Lettvin tried this without much success. Then one day he forgot to put a resistor into his electroplating circuit. Without the current-regulating device, a current many times higher than normal was inadvertently used. The accident turned the trick. In effect, it created a platinum surface studded, quill-like, with ultramicroscopic prongs capable of making delicate contact with nerve fibers.

This is only one among hundreds of problems of technique and interpretation that had to be solved before the M.I.T. investigators began achieving fruitful results about two years ago. A representative experiment might involve a frog looking directly at a large straight-edged form on the curved gray aluminum sheet. The edge of the form is fixed in position, and a microelectrode in a single fiber of the frog's optic nerve records no signals. Except for a low background hum, the loud-speaker is silent. It remains silent even when the form is made to move.

Things start happening with a small circle. Again, as with the other forms, there are no signals when there is no motion. But if the circle is moved, the fiber discharges, or "fires," and there is a "putt-putt" noise on the loud-speaker. Furthermore, any small form will cause the fiber to emit signals providing it has a positively curved, or convex, edge and providing that the edge is moving toward the center of the field of vision of that fiber. The significance of such provisions becomes clear when you consider that, in the world of the frog, small things with curved front ends are very likely to be insects. In fact, Lettvin and Maturana have called this fiber a "bug perceiver." Notice also that the fiber reacts only when the small object is moving. This fits in nicely with the observation that a frog will go after nothing but moving targets, and will starve to death in a cage that is filled with abundant supplies of freshly killed insects.

Further experiments reveal three other specialized fibers in the frog's optic nerve. The so-called edge detector emits a muttering sound of 30 to 40 discharges per second that is heard on the loud-speaker in response to the presence of a sharp, irregular boundary in the fiber's field of vision, whether that boundary is moving or still. (The contours of the boundary make no difference.) Another, the "event" detector, fires in response to moving edges or to changes in light and dark over the visual field—but only during the time of occurrence. Finally, there is the dimming detector, which produces discharges when its field of vision becomes darker, as would happen, for example, if a bird approached and cast a shadow.

SUCH findings have come as somewhat of a surprise to many researchers. It has long been known in a general way that nature tends to be compact and economical. But even so, the degree of economy demonstrated in the fundamental organization of the frog's optic nerve represents a brilliant and unsuspected confirmation of this principle. The nerve is adapted primarily for the perception of form and motion. It contains about half a million fibers, and nearly all of them fall into four and *only* four basic categories—those described in the preceding paragraphs. Some few fibers do not go to the same part of the brain where the great majority end; they have other functions.

But this is only the beginning of the story. Detailed anatomical studies of the light-analyzing apparatus in the frog's retina show that it includes four major, different types of nerve cells that can be distinguished under the microscope. The cell types seem to correspond to the four major fiber types. For example, the bug-perceiver fibers are wirelike extensions growing out of cells whose fine branches form characteristic "hedgerow" patterns. Fibers that detect sharp boundaries come from cells resembling flat-topped bushes, while the fibers that serve in detecting changes in light-distribution and dimming come from larger cells, the branches of which are arranged in double and in single layers, respectively.

Now let us follow the course of the optic nerve as it ascends toward higher brain centers. Picture the four types of cells arranged in the retina so that they form a

An accomplished science writer, MR. PFEIFFER is known to readers of NATURAL HISTORY for his introductions to the annual reviews of children's books and for his article "DNA: Master Substance of Life," for which he received an AAAS-Westinghouse Science Writing Award in December.

single layer or sheet of tissue. There are 500,000 cells in all (accounting for the 500,000 fibers that make up the optic nerve), and each one of them "maps" a small region of the retina. In other words, when an image falls on the retina each cell emits signals representing its own fragment of the image, and the total image is a mosaic of the entire sequence of subimages along the nerve sheet.

The fibers are scrambled in the optic nerve. They come together to form one great cable, but are so intertwisted and braided that each fiber may originate in widely separated regions of the retina. However, when the optic nerve reaches the tectum, which is the frog's visual brain center, an extraordinary unscrambling takes place. All the sharp-boundary fibers—those coming from the flat-topped cells in the retina—sort themselves out in such a way that their endings produce a single, thin, matted layer. Furthermore, the fibers end in the layer in positions corresponding to their starting positions in the retina, producing a new map in projection.

THE same thing happens with the three other types of fibers. Thus, the tectum includes four layers of maps, or systems of plotted positions, one on top of the other in the following order: edge map, bug-perceiver map, event-detector map, and dimming map. There is a further feature that, perhaps more than any other, indicates the incredible precision in the circuits of the frog's nervous system. The four maps are superimposed point for point. They are in registration—a registration as perfect as that of the four separate impressions that make a four-color print.

Also, the fibers somehow seem to "remember" this arrangement. If the optic nerve is completely severed, the fibers in the separated part that runs to the tectum degenerate and disappear, but the fiber stumps in the retina end of the cable start growing back toward the tectum. Within three months they arrive at their places in this visual center and form four mapped layers again, and, again, the maps are superimposed in perfect registration.

Similar phenomena had first been observed at other laboratories, but not with the same precision. Explaining them remains a major challenge. The regenerating fibers may be guided toward the brain by "directional markers" in the tissues along the way. Perhaps the markers are remnants of the old fibers that have disappeared but have left traces analogous to the ruts of an old roadway. As far as re-forming the maps is concerned, it may be that the tips of the four types of fibers are labelled with four distinctive chemical compounds (A, B, C, D), and that four related compounds (A_1, B_1, C_1, D_1) are present in the tectum, each concentrated at a different level. If so, the fibers might sort themselves out by a kind of chemical matching when they reach the tectum. But this remains only theory.

So much for an outline of the remarkable findings reported by the M.I.T. scientists. They present a number of implications, the most obvious being that the frog's brain is organized to an extraordinary degree, and everything from the functions and arrangements of the nerve cells to their interconnections proceeds according to detailed plans embodied in some sort of "blueprints." Recent research leaves little doubt that the blueprints are genes—giant molecules of deoxyribonucleic acid, or DNA—whose patterned structures control the synthesis of cell-building enzymes and other proteins ("DNA: Master Substance of Life," NATURAL HISTORY, December, 1960). A basic question remains: how do genes organize cells into certain patterns?

We have a great deal in common with other species or, to put it another way, the same basic design principles were utilized in the evolution of all forms of life. For example, take the four types of nerve cells in the frog's optic nerve, the cells specialized to detect particular elements of form and motion in the environment. As already pointed out, the cells can be distinguished under the microscope. They have characteristic shapes and the shapes mean something, for similarly shaped cells can be found in the retinas of many higher species.

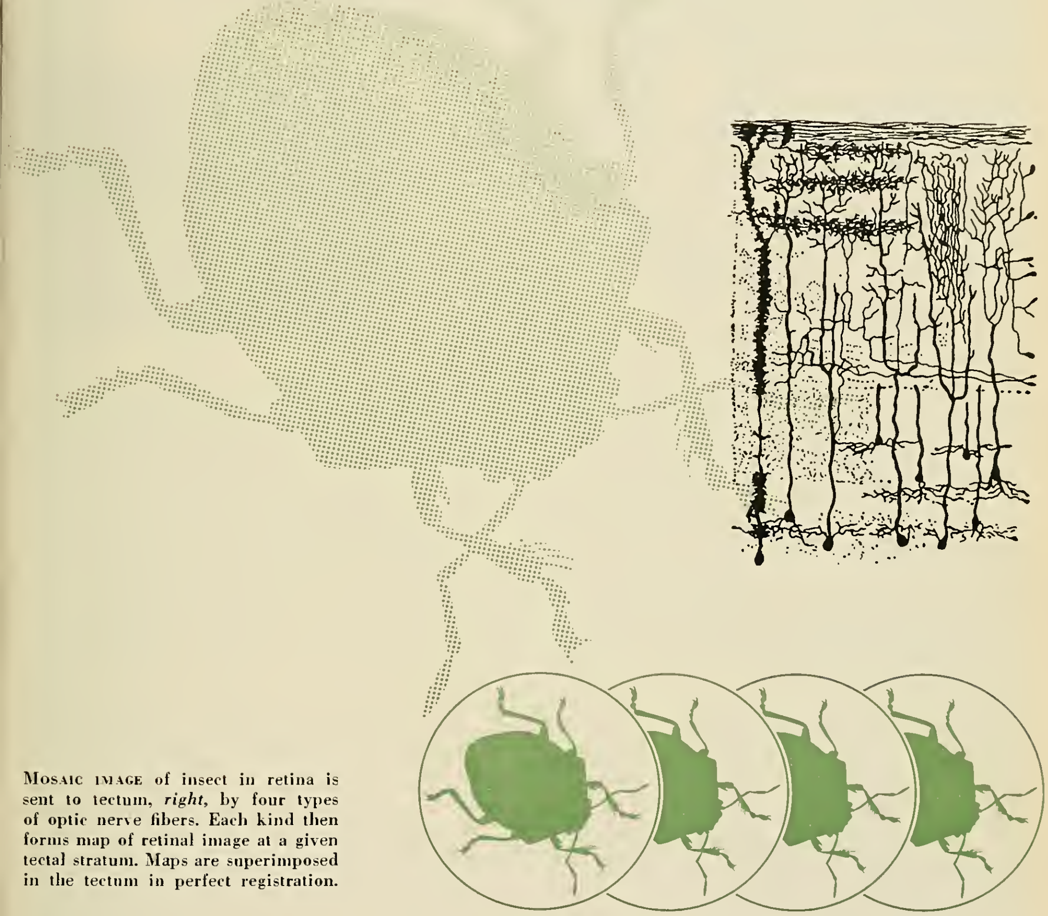
Do the similar shapes imply similar functions? Advanced species have a wider variety of detecting nerve cells, but among them are cells that closely resemble those found in the frog's visual apparatus. Are these cells specialized in all animal forms to respond to sharp boundaries and curved edges and dimming light and so on? There should be common features, because many species evolved in a world where prey was tracked and caught in a sudden pounce, and where enemies sprang suddenly from behind a bush or on wings from above. Of course, there is much more to life than hunting and being hunted. New problems and new methods of social co-operation have arisen with the coming of newer and higher species. The nervous system has evolved together with such developments, and species more advanced than the frog have types of cells that are not found in the frog.

While similarly shaped cells may imply similar functions, similar functions, in turn, may imply similar conditions in the struggle for survival. From this standpoint, the four distinctively shaped nerve cells in the frog's retina can be regarded as pictographs—symbols to be interpreted on the basis of many species. "Anatomy can be a kind of translating process," according to Lettvin and Maturana. "In the frog's retina we have four functions represented by four ideograms of a sort. Our problem is something like that of understanding an ancient language, of learning to read Linear B from clay tablets found in Crete. It is essentially a matter of anatomical deciphering."

There are interesting insights, too, at the philosophical level. Frogs cannot see all of the real world around them in the same way we do. In a basic sense they do not *need* to see all of the real world, most of which is utterly irrelevant to their way of life. This restriction is genetically built-in, as it is in all animals. As we have seen, the very structure of their eyes excludes much of what we think is the real world. The frog's eye is not merely a passive organ that takes in all visual information, come what may, and passes it on to the brain for analysis. Its eye is a selective device that excludes a great deal of what is happening in front of it.

For example, frogs do not see the six legs of an insect, or its delicate coloring, or the shape of its wings. They see objects with curved front ends that move in certain ways, stop, and move again; they see abstractions of reality. While frogs do not actually see whole insects, they do detect "insectness," the quality of insects in general—a universal insect, as it were. Their world is thus limited,

Drawings by Frank Haines



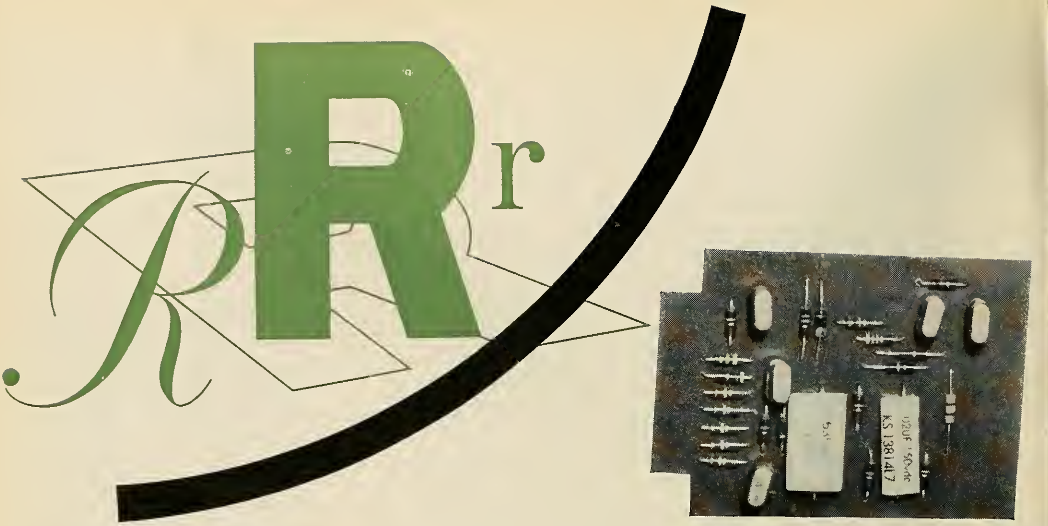
Mosaic image of insect in retina is sent to tectum, *right*, by four types of optic nerve fibers. Each kind then forms map of retinal image at a given tectal stratum. Maps are superimposed in the tectum in perfect registration.

but it is all the frog requires, and it is sufficient to maintain the species. Frogs have lived and flourished in the world for about two hundred million years.

It may be assumed that in more sophisticated organisms in the higher realms of the animal kingdom there is a comparable economy of endowment. More specifically, there is every reason to believe that the perceived worlds of all mammals, including primates and man, are limited to some extent, although not as limited as is the frog's world. Research currently under way at the Harvard Medical School, for example, reveals that the eyes of certain monkeys also contain nerve cells specialized to respond to selected stimuli in the outside world and to ignore other stimuli. The extent to which human visual systems exclude parts of the world remains to be determined, but like the frog, we see only what our eyes are built to see. Furthermore, it is highly possible that the portion that eludes us may be far larger than is suspected at present.

In any case, microelectrode studies of single nerve cells in frogs and other animals will bring us far better understanding of higher mental processes and of the neurophysiological basis of our own ideas and concepts. Out of all the small moving and crawling things that exist in the frog's world, out of all the different shapes and markings and countless details of structure, the frog's brain extracts only those features common to the vast majority of insects. Everything is excluded except what is necessary to the notion of insectness from the viewpoint of the frog.

This is a marvelously intricate and built-in process of exclusion and selection. An analogous process permits us to form more elaborate abstractions. Human visual centers are capable of scanning such overtly dissimilar things as the sides of a valley, a split stone, a mother and



Artificial nerve cell, at right, can respond to moving objects with convex edges, as do bug perceivers in frog's retina. Human abilities include abstracting the essentials from complex variations, such as many shapes "R" may take.

her child, or the sun and moon, and isolating the one significant quality that all these things have in common —the quality of twoness. Mathematics is a superstructure built on ever higher orders of abstraction, and so are all activities involving the use and recognition of symbols.

THINK of all the images a letter of the alphabet can make on the retina. It may appear as "r" or "R," close to us or far away, tilted or upside down, neatly printed or handwritten, in any color, and in any one of dozens of type styles, blocked out completely or indicated by a few suggestive strokes only. There are infinite versions of this single letter, yet we unconsciously rid any one of them of its peculiarities and recognize it.

Most of us take this ability for granted. But among the specialists busily engaged in analyzing the processes of abstraction are electronics engineers, for the work of Lettvin, Maturana, and their associates at M.I.T. is of practical significance. For example, Bell Telephone Laboratories scientists have constructed artificial nerve cells, or "neuromimes," which may be used either individually or in combination to do some of the things that nervous systems do. One such device is about the size of a playing card and contains five transistors and other electronic components. Hooked up to six photocells, or "electric eyes," it emits electrical impulses in response to moving objects that have positively curved edges, like the bug-perceiver cells in the frog's retina. The purpose of this research is to investigate the working of cells in an attempt to learn more about the human nervous system.

Many other laboratories are now designing complex circuits made up of similar elements in an effort to build improved electronic devices that make abstractions and recognize patterns. Existing large-scale computers can prepare adequate translations from Russian to English, but the Russian text must first be retyped and converted into a form for machine analysis (holes in punched cards or tape, magnetized spots on recording tape). The typing could be eliminated by equipping the machines with a photocell device that reads copy directly from texts. Such a device would work most effectively if it recognized Russian letters independent of type style and other variables.

A similar problem is involved in developing machines to recognize spoken words. Consider a voice typewriter that would have microphonic ears, take dictation directly by word of mouth, and print out the words immediately; or an electronic control for an industrial assembly line that would respond appropriately to commands like "Speed up to a hundred units per hour." Such machines are coming, but not until engineers learn to design electronic devices that recognize a spoken word independent of intonation, pitch, accent, and other voice characteristics.

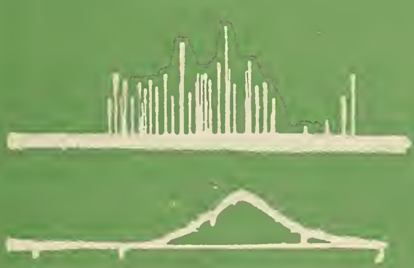
The operation of radar defense networks also presents major pattern-recognition problems. An approaching plane may be heading directly into the radar beam or cutting across it, climbing or diving, veering to right or left, nearby or at a distance. There are literally thousands of images that may appear on radar screens, and all of them must be identified, swiftly and accurately, as the same thing. Electronic plane-spotters, like voice typewriters and many other devices, must automatically make abstractions that, in a basic sense, resemble those made in the brain, which is the pattern-recognizer supreme.

SO the work of Lettvin, Maturana, and their co-workers is not an isolated investigation. Instead, single-cell microelectrode recording is a newly refined technique, yielding results of broad interest. The results apply not only to the frog's brain, but perhaps also to brains in general, and not only to neurophysiology and an understanding of higher mental processes, but also to the design of electronic devices, which represent an increasingly numerous assortment of specialized thinking aids.

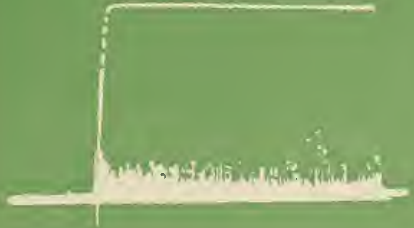
There is no better example of the essential unity of science. An entire complex of new directions in research and new pragmatic possibilities have resulted from investigations such as that designed for a fuller understanding of the nerve mechanisms triggering the jump of a frog.

Edge detector responds to a small black disk in field, stops when lights go out, resumes when they go on.

Bug-perceiver fiber fires at three successive passes of a small black disk through field at different speeds.



Spikes mark emissions of event detectors when black disk crosses their fields under brilliant illumination.

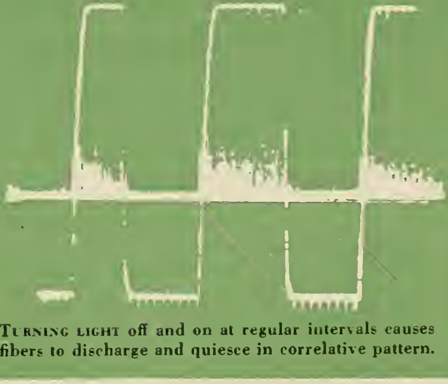


Dimming detectors discharge as their fields darken. Here, turning off the lights elicits lengthy response.

Response to edge of large black square that is moved into field and stopped continues while edge is in field.

Same fiber "ignores" two traverses of a black strip, which are recorded by a photocell monitoring the field.

In dim light, event detectors continue to respond to moving black disk. Steep curve is a calibration figure.



Turning light off and on at regular intervals causes fibers to discharge and quiesce in correlative pattern.

SKY REPORTER

Modern astronomical methods aided analysis of Great Galaxy

By Simone Daro Gossner

When astronomers tried to understand the structure of our own Milky Way Galaxy, they had at first little more than educated guesses on which to build their theories. The solution of the problem would have been even more elusive but for the existence of another galaxy, which proved to be an almost identical twin of our own.

The Great Galaxy in Andrómeda (see photograph, *right*) is barely visible to the naked eye, appearing as a small, hazy patch. It is known variously as the Andromeda Nebula (a relic from the days when such objects were thought to be gas clouds), M 31 (from its number in Messier's catalogue of nebulae and clusters), NGC 224 (its number in Dreyer's New General Catalogue), or simply Andromeda (somewhat of a misnomer, since Andromeda is merely the constellation in which it is located among many other galaxies).

When Galileo turned the first telescope to the sky in 1610, he discovered that many "nebulous" stars such as Praesepe and the Pleiades were aggregates of numerous faint ones. Optimistically, he and his successors assumed that all nebulae would prove to be star systems, if only they could be observed with more powerful telescopes. This was not to be, however, since some of the nebulae are truly gaseous. As for M 31, another three hundred years elapsed before its individual stars could be seen.

Before photography had sufficiently improved to be of service to astronomy, drawing was the only means of recording the appearance of celestial objects. The results depended, understandably, on the observer's artistic skill as well as on the power of his telescope. Even in the drawings of William Herschel, who had built the largest telescope of the eighteenth century, the Andromeda Nebula looked like an elongated blob without structure. Its spiral arms were seen—and drawn—for the first time *ca.* 1850 by William Parsons, third Earl of Rosse. With his huge (72-inch) reflector, known as the "Leviathan of Parsonstown," Lord Rosse detected the spiral structure of no less than 14 galaxies. He even convinced himself that he could see some of their individual stars, but in all cases these turned out to be foreground stars from our own Milky Way.

The spiral arms of Andromeda were at last resolved into stars shortly after the 100-inch reflector was placed in operation at the Mt. Wilson Observatory (1917). By the end of 1924, Edwin Hubble wrote that "under good observing conditions" the outer regions of the spiral were "resolved into dense swarms of images in no way differing from those of ordinary stars." In the same historic paper, Hubble gave conclusive proof that the nebula was an island

universe in its own right, outside the Milky Way's system.

The dense central part of M 31, called its nucleus, remained somewhat of a mystery for the next two decades. The nucleus in itself was no rarity: most galaxies have one. However, although it seemed reasonable to suppose that it consisted of a high concentration of stars, all attempts to verify this assumption had met with failure. In 1943, at last, M 31's nucleus yielded to the perseverance of astronomer Walter Baade, the efficiency of the 100-inch mirror, and the superior observing conditions resulting from the World War II blackout of Los Angeles. A photograph on red-sensitive emulsion revealed countless faint stars.

That these stars are recorded only on photographic emulsions sensitive to red light indicates that the stars are very red. Baade noted their great similarity with the stars in globular clusters, and the contrast they offered with those in the spiral arms. In particular, he pointed out that the very hot, blue supergiants, which occur in abundance in the dust and gas of spiral arms, are totally absent from the nucleus and globular clusters. In other words, the Andromeda Galaxy contains two distinct stellar popula-

Great Galaxy in Andromeda strongly resembles Milky Way.

tions: the blue supergiants and other kinds found in the arms, which he called Population I, and the faint red stars of the nucleus and globular clusters, which he called Population II. Baade's discovery proved to be valid also for the Milky Way and other galaxies. His basic classification underwent many refinements in the last decade. It soon became apparent that Population II stars are much older than the stars of Population I; as a result, the concept of stellar populations has become the foundation of modern theories concerning stellar evolution.

The similarity between the Andromeda Galaxy and the Milky Way is not limited to their stellar populations. Their dimensions are approximately the same, with diameters of the order of 80- to 100-thousand light-years (500 to 600 million billion miles). They contain the same types of sky objects: cepheid variables, gaseous nebulae, novae, globular clusters, and dust clouds. The spiral structure is moderately well developed in both. Observations at radio wave lengths have revealed that their interstellar hydrogen is distributed in essentially the same way.

As a final touch, M 31 boasts of two companions, just as the Milky Way has its Magellanic Clouds. They are NGC 205 and NGC 221, distinctly visible in the picture, *above*, as two hazy ovals. NGC 205 is the larger of the two, and farther away from M 31. Both are dwarf elliptical galaxies, composed of very faint red stars like those in Andromeda's nucleus. They were resolved into stars by Baade in 1943.

The Great Galaxy and its companions belong to the cluster of galaxies—called the Local Group—of which the Milky Way is also a member. In other words, they are our fairly close neighbors in space. In spite of this, the determination of their distance has proved a thorny problem. First estimated by Hubble at one million light-years, the distance was later revised downward to 750,000 light-years. Ten years ago, however, it was discovered that the entire distance scale of the universe, as used in current studies, was in error by at least a factor of two. Since then, astronomers have become cautious in quoting distances. Estimates of M 31's distance from us range from 1½ to 2½ million light-years, with two million light-years (approximately 12 billion billion miles) the most generally accepted figure.

THE SKY IN NOVEMBER

From the Almanac:

First Quarter	November 5. 2:15 A.M., EST
Full Moon	November 11. 5:04 P.M., EST
Last Quarter	November 18. 9:10 P.M., EST
New Moon	November 27. 1:30 A.M., EST

For the visual observer:

Mercury (—0.8 magnitude) will appear in the morning sky until November 25. On that date it will be in superior conjunction and will enter the evening sky. The planet will rise an hour and fifteen minutes before sunrise on November 1, thirty minutes before sunrise on November 15, and at sunrise on November 30. Because of its proximity to the sun at time of conjunction, it will be observable only during the first few days of the month.

Venus (—3.4 average magnitude for month) will be in the evening sky until November 12. At inferior conjunction on that date, it will then enter the morning sky. It will set fifteen minutes after sunset November 1, but will be too close to the sun to see during the first two weeks of the month. It will rise thirty minutes before sunrise November 15. and two hours before on November 30. By month's end it should be found easily in the southeast at sunrise.

Mars will be visible for most of the night throughout the month. It will rise in the east at 11:00 P.M., local time, on November 1. 10:30 P.M. on November 15, 10:00 P.M. on November 30, and will be nearly overhead at sunrise. As in previous months, it will continue to brighten (from +0.7 to +0.3 magnitude) as it comes closer to earth.

Jupiter, in Aquarius (—2.1 magnitude), will set on the southwestern horizon at 1:00 A.M., local time, on November 1. at midnight on November 15. and at 11:00 P.M. on November 30. The planet may be found low in the southeast at sunset, passing across the meridian in early evening.

Saturn, in Capricornus (+0.9 magnitude), will be in the southern sky at sunset. It will set in the southwest at 10:30 P.M., local time, on November 1, at 9:45 P.M. on November 15, and at 9:00 P.M. on November 30.

Two meteor showers will occur in November. The Taurids will reach their maximum of approximately 15 per hour on November 5. This shower extends over a period of several weeks before and after maximum frequency. The Leonids. November 16, will not be too favorable this year, because the moon will be gibbous on that date. Normally, this shower also has a maximum of 15 meteors per hour, but it must be expected that moonlight will prevent the observer from seeing all but the brightest ones.

Astronomical Units of Distance

Just as it would be impractical to measure the distance from New York to Los Angeles in inches, expressing astronomical distances in miles is too unwieldy for scientific use. Astronomers have chosen large units that enable them to express enormous numbers with relatively few figures. Within the solar system, their unit of measurement is the earth-sun distance, or *astronomical unit* (1 astronomical unit is about 93 million miles). In the universe, the most frequently used unit of distance is the *light-year*, which is the distance light will travel in the course of a one-year period (1 light-year equals approximately 6 trillion miles).

On the preceding pages, MRS. GOSSNER offers the ninth in her 1962 series—a survey of the celestial sphere.

To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.

north
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
URSA MAJOR
BIG DIPPER
MIZAR
ALCOR
LITTLE DIPPER
NORTH POLE
POLARIS
northwest
HERCULES
DRACO
CAMELOPARDALIS
CASSIOPEIA
CEPHEUS
LYRA
VEGA
CYGNUS
PERSEUS
ALGOL
LACERTA
ANDROMEDA
TRIANGULUM
ZENITH
ARIES
PEGASUS
west
ALTAIR
AQUILA
PISCES
10
CETUS
7
AQUARIUS
JUPITER
4
SATURN
CAPRICORNUS
SCULPTOR
FOMALHAUT
PISCIS AUSTRINUS
southwest
GRUS
south
TIMETABLE
November 1 10:00 P.M.
November 15 9:00 P.M.
November 30 8:00 P.M.
(Local Standard Time)

LOW-GROWING *Brachycereus nesioticus* has thick spines that prevent reptiles from eating the succulent stem parts.

GIANT PRICKLY PEAR, *Opuntia echios*, and columnar *Jasminocereus howellii* grow in cactus forest on Santa Cruz Island.

The Giants of Galápagos

On these isolated islands, reptiles and plants have evolved concurrently

BY E. YALE DAWSON

Of all the families of plants peculiar to the New World, the Cactaceae is perhaps the most conspicuously distinctive. This is not only because of the extraordinary diversity of form, spination, succulence, and floral characters, but also because of the remarkable range of habitats. Members of the family are found from tropical wet forests or arid thorn thickets at sea level to great mountain heights, and from the hottest deserts to blizzard-swept northern prairies. Thus, one finds cacti in all of the Latin American countries, throughout the United States, and far north into Canada. The cacti have occupied most of the islands of the Caribbean Sea, but with the exception of a solitary and somewhat questionable epiphyte in Africa, they did not cross the Atlantic Ocean until European ships first transported them into the Mediterranean. Nor did they migrate far into the Pacific. But by the same vagaries of wind or current that brought many of the other remarkable inhabitants to the Galápagos Islands, the plants arrived there and underwent a striking development in their most western outpost in the Southern Hemisphere.

The cacti of coastal Ecuador and Peru today include a number of diverse types, from shrubby opuntias and solitary melocacti, to columnar or candelabra forms of *Armatocereus* and *Neoraimondia*. One finds these several forms in the arid, rocky hills, in thorn thickets, and down to the edge of mangrove swamps near the Guayas River in Ecuador. When one stands beside this river near Guayaquil and sees the islands of vegetable debris floating down to the sea, it is not difficult to visualize a piece of cactus—fruit, seeds, or stems—moving slowly westward with the Humboldt Current toward the Galápagos Islands.

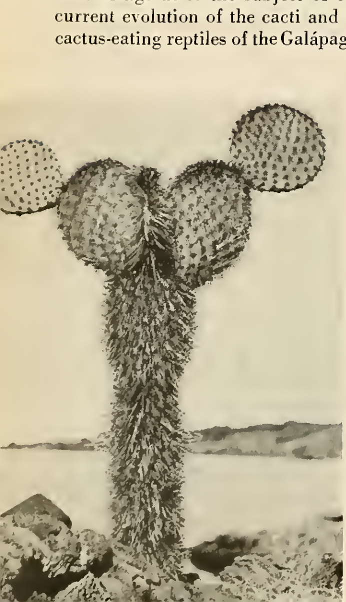
The Humboldt Current sweeps up the west coast of South America with cold water from the Antarctic regions. Just short of the Equator, roughly opposite the border between Peru and Ecuador, it turns due westward into the Pacific and, except for the Galápagos Islands some 650 miles seaward, bathes no more land on its way to the far Marquesas. It is clear that cacti have managed to make this 650-mile crossing from the mainland on several occasions. At least three extant groups have so successfully established themselves that a remarkable interisland evolution has occurred in them that

Young tortoise, here feeding on *Opuntia* flower, also eats fallen pads and fruit. Plant adapted to animal's predation.

Land iguana, a cactus eater, is not large enough to pose a serious threat to plant's existence. This animal lives on

provides the most striking features of the low-elevation flora there today.

Three distinctive cactus types now live in the Galápagos Islands. The least abundant and smallest is the exceedingly drought-resistant *Brachycereus nesioticus*, which occurs on barren lava flows. It is a low plant accessible to whatever herbivorous animal life may exist in its desolate realm, but its stems are so spiny that the succulent parts are completely hidden under impenetrable armament. This brings us to the subject of concurrent evolution of the cacti and the cactus-eating reptiles of the Galápagos.



That the cacti may have arrived on the islands ahead of the tortoises. *Testudo elephantopus*, is suggested by the fact that they represent practically the only green vegetation there during the dry season. For several months the lowland regions pass through a severe drought, during which scarcely a leaf grows on a bush or a tree. The survival of the reptiles that first accidentally arrived on the shores from the mainland may well have depended upon the occurrence of the succulent cacti as a source of food and water during the critical dry season. At any rate, the cacti and the reptiles, especially the prickly pear and the tortoise, seem to have evolved side by side within the islands. each in relation to the other.

Before man came to the Galápagos Archipelago, the giant tortoises occurred in countless numbers on a majority of the islands. Judging by the habits of the survivors today, the tortoises must have come down to the coast during the dry season and subsisted on the succulent. leaflike pads of the giant *Opuntia* cactus, which has managed to survive and continues to provide food for the tortoises today. This has been accomplished in two ways. The seeds of *Opuntia* are large and sprout with the first rains of the season. The young plants, which grow rapidly during the brief wet periods,

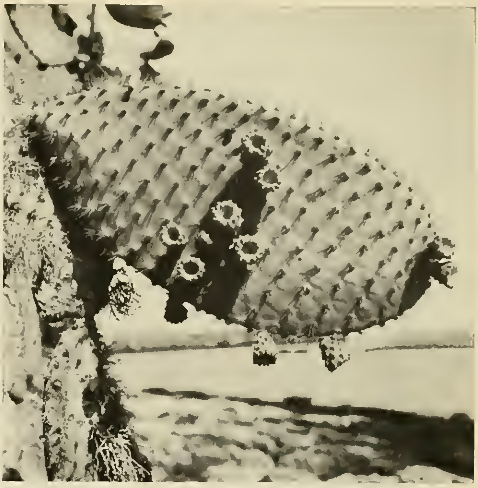
Pads of fast-growing, young *Opuntia* are soon out of reach of the tortoises.

are completely covered by spines that discourage the tortoises from gaining access to the succulent parts. In a few seasons the plant is producing pads well out of reach of the tortoises. As the plant grows older and larger the spines of the lower trunk gradually become farther apart, fall off, and are replaced by a woody trunk covered with a coarse, papery bark. which is not eaten by tortoises. The upper branches grow out into a leafy crown; at the beginning of each wet season the pads fill out, become turgid with water, and break off as their weight increases. This litter of fleshy pads and fruits, which remains succulent on the ground after the drought has begun, has, over the centuries, provided the tortoises with their dry season sustenance.

Abundant sprouting of cactus seeds has been aided by their deposition in tortoise feces. (The same aid to the sprouting of Galápagos tomatoes has recently been reported.) It may be said that giant tortoises in the islands are filling a niche inhabited by mammalian herbivores elsewhere, but today they are suffering in competition with cattle. goats. and pigs, which men have introduced into the area.

Another reptilian herbivore once common but now much reduced in the cactus forest is the land iguana, *Conolophus subcristatus*, but neither its size, abundance, nor appetite could have compared with those of the tortoise as prime factors in directing the

in island where neither tortoises nor goats forage on the cactus, whose pads, therefore, still droop to the ground.



SPINES on fruiting pad of *Opuntia echios* are shorter and softer than thickly growing ones that protect basal parts.

evolutionary trends of the *Opuntia*.

An indication of the effect of animals on the development of the arborescent habit among Galápagos opuntias is seen in those islands of the group where tortoises or their remains are unknown. There, the opuntias are low, shrubby species quite unadapted for protection from browsing reptiles.

One may also speculate that the huge proportions of the tortoises on the Galápagos may result in part from the survival value that accrues to large size in obtaining food and water from arborescent cacti during the rigorous times of drought.

Today the giant cacti remain in impressive dominion over the vegetation of the drier parts of the islands, although the tortoises have been destroyed or pressed back on the larger islands to a few remote refuges beyond the encroaching habitations of men. The two giant cactus types that occur are commonly found in association. but on nearly every island, specific and subspecific variations exist as a result of evolution through isloation and inbreeding of populations. Let us first note some of the characters and differences of the giant opuntias.

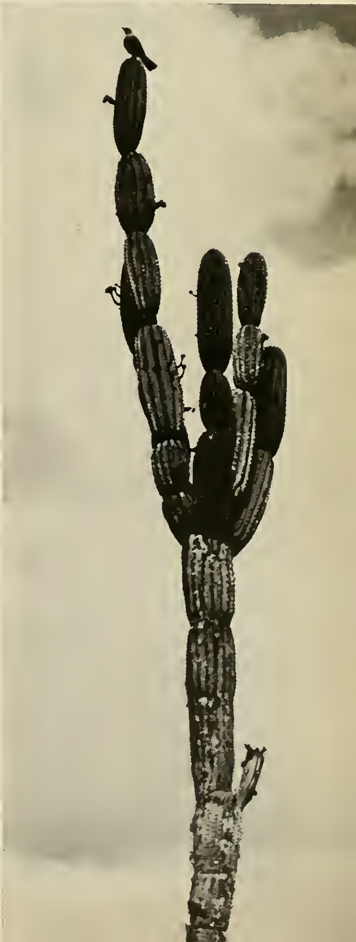
Five species of arborescent prickly pears have been described. and there may be more as yet inadequately distinguished. All of these plants are of large size and form heavy trunks with scaly bark. *Opuntia megasperma* achieves trunk diameters to $4\frac{1}{2}$ feet — perhaps the largest in the cactus family. Were one to observe only a portion of the trunk from a little distance, he might mistake it, in color, texture, and size, for that of a pine tree. The trunks of *Opuntia echios* on Santa Cruz Island are more slender, but may be nearly 2 feet in diameter.

VARIATIONS in the crowns are noticeable. Some species produce only erect pads that form a compact, dense, rounded crown, while others develop drooping, pendent branches and pads that today, in meeting much-reduced browsing pressure by the reptiles, may even touch the ground.

All of these succulent plants are provided with a peculiar, netlike vascular system that is best seen in fallen pads that have rotted, eroded, and been cleaned on the ground until only the pad skeleton remains. This skeleton also persists in the oldest trunk parts. which become thicker and more woody as successive intercalary layers of the vascular sheets develop.

The spines are exceedingly variable, but in every case the juvenile plants, from 2 to 6 feet in height, are the most heavily armed. Some remain spiny; some develop bristles in the upper parts: some are nearly spineless in the upper, reproductive portions.

For many years it was thought that only a single species of arborescent



BIRDS are attracted by red berries of the candelabra-shaped *Jasminocereus*.

Opuntia occurred in the islands, but as details of flower, fruit, seed, and spination were closely observed, a complex assemblage of more or less distinct species and subspecies became evident. On the 1932 expedition of the California Academy of Sciences, John T. Howell made the first comprehensive collections of cactus flowers and fruits and discovered among these a number of distinctive specific characters. Most remarkable are those of the fruits, which vary in different species from 2 cm. to 17 cm. in length. The fruits of some species take as long as two years to ripen, and in so doing produce the largest seeds known in the cactus family — 18 mm. long. Other species, soon after flowering, drop their fruits to the ground where the seeds quickly mature, aided by the fruits' watery pulp.

Apart from the low *Brachycereus* and the several opuntias, one other form of cactus has evolved widely in the Galápagos Archipelago. First described by Abel du Petit-Thouars of the French *Venus* Expedition in 1841, the giant candelabra cactus, *Jasminocereus*, has been known for over a century, but was always supposed to constitute a single species. Recent studies of fruits, flowers, and vegetative characters indicate that several distinct species and subspecies are present on the different islands.

In the Galapagos, Dr. Dawson is perhaps best known for his studies of Pacific seaweeds. A Professor of Biology, University of Southern California, he is also with the Allan Hancock Foundation.

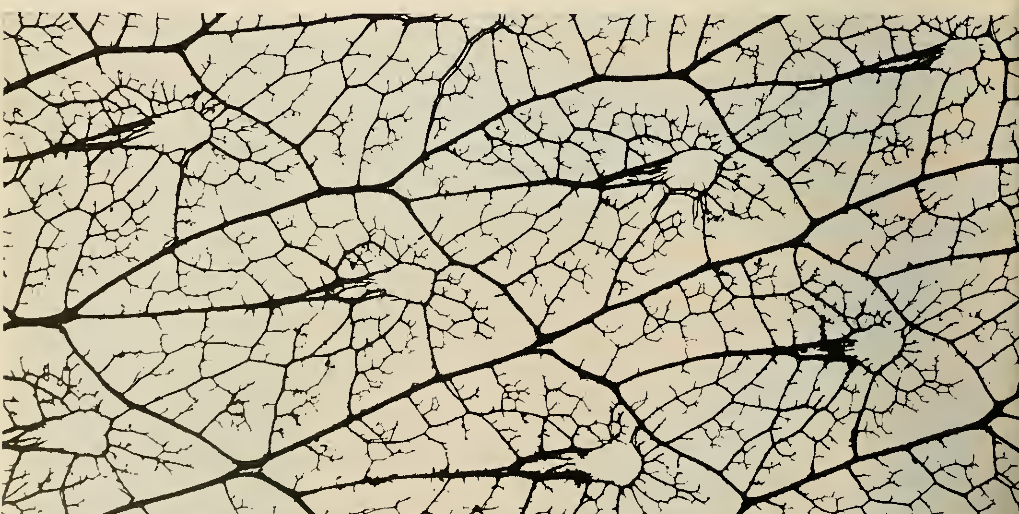
showing an evolutionary pattern much like that of the opuntias—a partial or complete differentiation in each isolated population.

The huge *Jasminocereus* is a night-flowering plant whose purplish-brown buds open to expose a long-throated, creamy white interior. Nocturnal insects, notably the hawk moth, pollinate the flowers, and the fruits ripen as red, spineless berries filled with small black seeds in a fleshy, white pulp. These provide meals for some of the fruit and seed-eating island birds, including the ground finches made famous by Charles Darwin.

Because they are of such recent volcanic origin, the Galápagos Islands are largely covered with lava and cinder fields bearing a scant cover of soil. In some of the higher interior hills some soil has accumulated from the heavy vegetation that is sustained during the rainless season by the wet fogs *(garuas)*, but the cactus forests are primarily on the arid coastal lowlands or on the bottoms of hot, lava-floored craters where they thrive with little competition from other plants.

One of the finest and most picturesque cactus forests is on Santa Cruz Island at the new Darwin Research Laboratory. The plants are as tall as any in the islands, and the lava cliffs and ridges around the bay shore provide striking elevation for these massive trees and spires. During the wet season, a mixed, leafy thorn vegetation, including such plants as *Prosopis*, *Croton*, and *Coldenia*, develops and partly obscures the cacti that dominate the lava during the dry season of complete leaflessness.

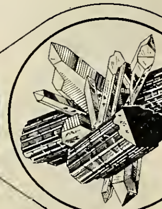
Of all the biotic communities of the Galápagos Islands, that of the giant cactus forest is now most favored for critical study, for the Darwin Research Station, situated in its midst, provides the biologist with modern research facilities in what, but a few years ago, was one of the most unfrequented spots on the globe. The forest stands on a seashore where marine iguanas, *Amblyrhynchus cristatus*, forage the intertidal seaweeds, and where the rocky ground is frequented by multitudes of lava lizards. The undershrubbery teems with remarkably tame birds. Grasshoppers leap through the thickets; insects probe the flowers, and at dusk the island bats wheel among the columns. The tortoises and land iguanas have disappeared here, but, with the protection now afforded them, the colonies elsewhere on the island may survive and spread, and one day again may move into the presence of man in the giant cactus forest.



Vascular pattern of a prickly pear pad is often seen on the ground after its succulent parts have been rotted away.

World's largest prickly pear species, *Opuntia megasperma*, *right*, may attain a trunk diameter of more than four feet.

NATURE IN ROCK & MINERAL



By Paul Mason Tilden

During the twenty years between 1830 and 1850. two events of the greatest mineralogical interest occurred in the United States. events that were to exert a profound influence both on the economic development and—more subtly. perhaps. but nonetheless as certainly—on the total social structure of a young nation. Both of these events involved the discovery of vast quantities of copper and gold. two of the rather few elements that occur in the earth's crust uncombined with other elements.

The first discovery (in truth. it was a rediscovery. as we shall see) involved immense deposits of native copper in the Upper Peninsula of Michigan—the first truly great copper strike since the slaves of the Roman Empire were put to work raising the red metal from the Rio Tinto mines of Europe's Iberian Peninsula. The second discovery initiated an outpouring of gold from the placers and lodes along the western slopes of California's Sierra Nevada. The opening and looting of these two treasure houses are long stories in themselves. were they to be told in full. and we shall only attempt to dip briefly into the first. reserving the second for a future installment.

As early as 1636 the Jesuits. who had followed the French trappers and explorers into the vast forests of the Lake Superior country. had indicated a belief that somewhere along the shores of that great fresh-water sea there were easily accessible deposits of native copper. Most of their information on the alleged mineral wealth of the area was quite likely garnered from the Indians of the region. who were themselves entirely uninterested in mining; the Jesuits fully realized that the Indian reports were probably liberally garnished with superstition and exaggeration. Nevertheless. in a report dated 1659. the Jesuits ventured to say that the Lake Superior region was ". . . enriched in all its borders by mines of lead almost pure and of copper all refined in pieces as large as the fist. . . ." Native lead. as most rock and mineral collectors know, is a great rarity in nature, and to this extent the report was a fantasy. The second part of the announcement eventually proved to be not only truth. but understatement.

To the southeast of the Upper Peninsula. spreading fanlike through Lower Michigan and into Ohio as far as the Ohio River, was an area in which the people who settled, farmed. and built highways constantly found corroded and waterworn lumps of native copper in soil and gravel banks, and among the cobbles and sands of watercourses. There were no known sources of native copper either in Lower Michigan or in Ohio, but it was suggestive to the more thoughtful that the apex of the fan pointed in the general direction of Lake Superior. In the earlier years of the nineteenth century. many believed that there was an abundance of copper somewhere to the north of the fan. but the natural agent of transportation generally invoked to account for the straying nuggets was a "universal flood" of earlier time that originated in Arctic regions and poured southward over the Northern Hemisphere. Such an outgushing of water from the North was also made to account for other phenomena we now recognize as the handiwork of continental glaciation: erratic boulders. striated cobbles and ledges, moraines. and so forth. (The studies and speculations of Jean de Charpentier and Louis Agassiz concerning the true nature of such phenomena had not been widely accepted in this country at the time of the copper lode discoveries in Michigan. In any event, so far as the erratic copper was concerned, they would merely have changed the natural vehicle of transportation.)

These considerations were sufficient to send many an explorer and prospector to the shores of Lake Superior, and. at a date tentatively set at about the year 1830, the first discoveries of metallic copper were reported from the Keweenaw Peninsula—that thumb-shaped land projection jutting about 80 miles into the

lake from the north shore of the Upper Peninsula. From this time until about 1841, prospecting activity increased in the area, and a number of modest copper discoveries were reported.

Finally, in 1841, Dr. Douglass Houghton, a botanist and physician who had received an appointment as the young state of Michigan's first official geologist —largely, perhaps, on the basis of his keen powers of observation—gathered together all the evidence and made a fairly detailed report to the State Legislature on the occurrence of native copper in the Upper Peninsula. The report, of course, immediately became public property, and a short time later mining operations began at a number of points on the Keweenaw Peninsula, with spectacular results. Prospectors, explorers, and the inevitable speculators flocked into the peninsula in such numbers that by 1845 "the shores of Keweenaw Point were whitened with their tents."

MASS COPPER is seen in dark areas of 1853 woodcut of Keweenaw mining operation.

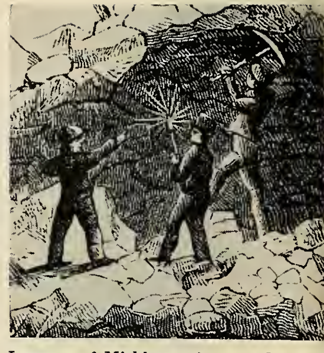
The origin of the "drift" copper of Lower Michigan and Ohio was now clear. In a narrow belt of geologically ancient rocks that striped the Keweenaw Peninsula lengthwise and included conglomerates, sandstones, and innumerable flows of basaltic lava, probably of late Precambrian age, was native copper in prodigious quantity, filling the cracks, fissures, and gas pockets of the lava, and in places forming the matrix for the pebbles of the conglomerates.

First to be worked were the so-called mass copper, or fissure veins, of the basaltic lavas, some of which yielded riches that were embarrassingly great. What does one do with a mass of nearly pure copper weighing twenty tons? Or with a "nugget" of a hundred tons? How raise it to the mine head? Such masses were at the same time both hard and yielding, like a metallic putty. They were proof against the power of gunpowder, and the blowtorch was still to be invented. Clearly, there was but one way to deal with the huge copper slabs and sheets—with the sledge hammer and cold chisel,

and that is the way the miners of the Keweenaw sliced the copper into smaller chunks. A Boston visitor to the Michigan copper country has furnished us with a firsthand account of this tedious process.

"The Masses are separated into manageable blocks," he reported, "solely by the hammer and chisel: one man holding the chisel, while two others strike alternately with seven pound hammers. . . . In this way, by the successive removal of small narrow chips, still increasing in length, until this reaches the thickness of the mass, the separation is finally effected. . . . A mass of eighteen inches in thickness and four feet across, will . . . require eight days to divide it."

Other schemes for dividing the copper masses had been devised from time to time, the Boston visitor noted: among these was the use of a circular saw. But the occasional thin veins of quartz that were encountered in some of the masses caused "the speedy destruction of the saw," and the idea was abandoned. The largest mass of native copper ever recovered from the Keweenaw mines, it might be noted, weighed about 500 tons!



Interior of Michigan mine was depicted at mid-nineteenth-century peak of industry.

For approximately nine years, or until about 1850, the entire production of the metal came from the crack-and-fissure veins of the basalt. Then it was discovered that, in certain beds of this plutonic rock, myriad tiny cavities, or "vesicles," originally produced by the expansion of steam or other included gases upon extrusion, were partially or wholly filled with native copper. This "amygdaloidal" basalt eventually proved to be the backbone of the copper industry on the peninsula, despite the relatively small size of individual "nuggets." One such basaltic flow was known as the Kearsarge Amygdaloidal Lode; all told, this was mined for an almost continuous length of seven miles along the "strike," or trend, of the rock formation, and up to two miles down its "dip," or inclination from the horizontal Stockholders in the Kearsarge Lode were rewarded with a total of more than fifty millions in dividends over the years during which it operated!

From the amygdaloidal basalts there also came dividends of another sort in the form of beautifully crystallized specimens of calcite, epidote, quartz, chlorite, and a number of commoner minerals. Equally fine specimens of the minerals peculiar to basaltic rocks were recovered with the copper. Among these were prehnite, the hydrous silicate of calcium and aluminum, in striking sea-green masses and crystals; datolite, the boro-

Slow, arduous method of separating the copper blocks of unwieldy size during the mid-nineteenth century is illustrated in this woodcut. With seven-pound hammers,

silicate of calcium, sometimes with enough included native copper to color it pink; laumontite, another hydrous silicate of calcium and aluminum; colorless analcime, a hydrous aluminum silicate; apophyllite, a hydrous silicate of potassium and calcium, and many other showy minerals that, like specimens of native copper of the region, are even today occasionally available to collectors through the various rock and mineral magazines.

In 1861, a third type of copper lode came into prominence — the so-called conglomerate lode, in which the matrix, or binder, for rocks and pebbles of a conglomerate was replaced by native copper. (In fact, in some places both the pebbles and matrix themselves were of copper.) It was upon such a copper-conglomerate ore body that the famous Calumet and Hecla mine was sunk in 1864, eventually to be driven some 9,000 feet down the dip of the formation, with some 200 miles of lateral tunnels.

THERE were two versions of the story about the discovery of the conglomerate lodes. The first, and least romantic, relates how one E. J. Hulbert, prospector, discovered the copper-laden conglomerate in a most orthodox manner— a story of patient search and mineralogical knowledge rewarded. The second account placed the same Hulbert on the scene, but indicated that he was in search of a lost pig rather than a copper lode. Attracted by the squealing of the pig, the story runs, Hulbert located the animal at the bottom of a ten-foot shaft in the woods, and proceeded to its rescue. It was then that the man became aware of the nature of the pit. It had been sunk, by persons unknown, on an exposure of

two men alternately strike a chisel held by third. Blowtorch had not been invented.

conglomerate, the matrix of which was solid copper. The heyday of the so-called conglomerate lode was at hand.

But who were the persons who had first driven the pit? This was not the first occasion on which prospectors had noticed the traces of prehistoric mining; indeed, some of the prospectors of the Upper Peninsula spent their working hours searching for the pits and cavities of prehistoric mining activity rather than for the geological clues to the metal. Such ancient traces were regarded as fairly sure indicators of valuable lodes, and the number of working mines that sprang up on sites of old diggings vindicated the judgment of treasure seekers.

Within the copper pits of the ancients were commonly found the rude accouterments of the mining trade—stone hammers and mauls, copper chisels, pointed tools of various sorts, and even rude wooden shovels, the latter partly preserved by the water and accumulated debris of the pits. One ancient opening on the peninsula measured 120 feet in diameter and was 15 feet deep. In some pits the prehistoric miners had obviously encountered the same trouble in detaching usable pieces of the metal as had their successors; large hacked masses of copper, along with broken mauls and wedges, seemed to indicate abandoned efforts. These people, still unknown, were

PAUL MASON TILDEN, editor of the National Parks Magazine, began this column on the staff of Nature Magazine and is continuing it here.

the actual discoverers of the Keweenaw treasure house. They were believed to have been contemporary with, but not a part of, the Hopewell civilization, which flourished farther to the south perhaps 2,000 years ago. Archeologists think that the primitive miners left their mines hurriedly, discarding even their tools, but the reason for their hasty departure is still a matter for speculation.

In any case, upon the rediscovery of the mines that were pioneered by the ancients, the production of copper in the United States jumped from a few hundred tons a year to many scores of thousands. The heyday of mining in the Upper Peninsula of Michigan came in 1916, during the First World War, when the region produced some 135,000 tons of the red metal. All told, more than four million tons of copper have been won from the geologically puzzling basalts and conglomerates of the peninsula, and the district is now almost exhausted, commercially speaking. But for rock and mineral collectors, there are still treasures to be recovered from the dumps and workings of its abandoned mines.

This list details the photographer, artist, or other source of illustrations, by page.

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3-4—Joseph Sedacca
10-11—Courtesy J. T. Robinson
12-18—Ronald Singer except 13-bot. AMNH after Ronald Singer; 16-Courtesy J. T. Robinson
19-21—A. L. Schweizer
22-28—Audrey M. Glauert except 25-top right, Margaret J. Thornley and R. W. Horne; 28-top, R. W. Horne
29-Margaret J. Thornley and R. W. Horne
30-39—Lee Boltin
41-47—Drawings by Frank Haines; photos 42-43 top and 46-Bell Telephone Laboratories
48-49—Harvard College Observatory
50-51—Sky Map after Henry M. Neely
52-57—E. Yale Dawson
61-63—Harper's New Monthly Magazine, 1853

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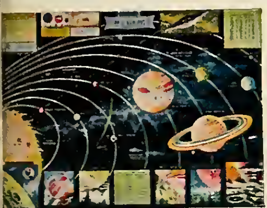

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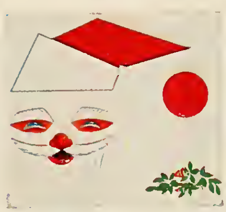

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COVER: This plate shows, from top to bottom: two adult lantern flies, *Fulgora lanternaria;* an adult cicada, *Fidicina mannifera* Fabr.; one of its nymphs; a lantern fly with folded wings; and one of its young. That in itself is not unusual. However, the painting was executed by Maria Merian, an intrepid woman who, in 1700, ventured into the Surinam jungles to study insects. The lantern flies startled her with their light, but modern scholars are uncertain about exactly when the insects are able to glow. Further information about the artist is on page 28. Lee Boltin took the photographs of the illustrations in Madame Merian's book.

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Reviews

A Christmas survey of children's science books during 1962

In the children's science book field we stand today just about where we stood several years ago: publishers in general continue to be followers rather than leaders. Bad or indifferent books continue to outnumber good ones, and even the best of the lot tend to be well-produced versions of what has been tried many times before. In other words, for all the vast numbers of books turned out, the dearth of original ideas remains as striking as ever.

The situation contrasts sharply with the trend of the times in other areas of science education. To take only one example, the National Science Foundation, which has actively supported improved courses in physics, mathematics, chemistry, and biology, is now considering proposals to introduce anthropology and archeology into high school curriculums. This development may be expected to have wide repercussions. For one thing, it may well stimulate fresh interest in revised methods of teaching the humanities, since research on early man involves art, language, and social studies, as well as scientific disciplines.

That things are stirring elsewhere is indicated by the many responses to last year's Natural History survey of children's science books. The editors received letters requesting copies of the survey not only from public libraries, state and municipal departments of education, schools, and universities offering courses in library science, but also from individual parents, teachers, and persons who simply wanted guidance in selecting appropriate book gifts. In all, some 5,000 reprints were distributed.

Some of the comments in the letters are of special interest. Our correspondents expressed considerable concern about "wading through increasingly large numbers of books," and "the flood of books in this field." The representative of a large public library system in Massachusetts criticized "books...which are repetitious and seem put together from other books." In an effort to do something about the selection problem, a group of California libraries has developed a checking policy of its own—one designed to supplement and extend services provided by the survey. Other letters mentioned use of the survey in talks to parents and teachers, and in helping to determine what books to order in quantity with funds provided under the National Defense Education Act.

Although publishers seem less sensitive than librarians and scientists to the need for change, their lists still feature a certain proportion of books that are distinctly better than average. Those dealing with specialized areas of science are reviewed in our third annual survey, which, like previous surveys, is confined to material intended primarily for children twelve years of age or older. Books involving several research fields include such well-edited volumes as L. Sprague de Camp's *Man and Power* (Golden Press) and Michael Blow's *Men of Science and Invention* (American Heritage). Also worthy of notice is the "Immortals of Science" series (Watts), which consists of biographies of Aristotle, Newton, Maxwell, Koch, and other great investigators.

These are fine books in many ways. The explanations are uniformly clear and direct, which is saying a good deal. (If straightforward presentations were easy, the demand for professional science writing would be far less urgent.) Critical experiments are discussed in the context of their theoretical and cultural significance. Even more heartening, we find less and less use of synthetic little anecdotes about poverty-ridden scientists who stomp triumphantly from laboratories to announce, usually to startled but understanding wives, sudden insights into nature's mysteries.

On the other hand, the feeling of having been through it all before is uncomfortably present in many of the books. Of course, a good thing is often worth doing over again, but the trouble with rehashing is that as a rule it points toward a lack of imagination. It indicates that someone has taken the easy way out and, instead of thinking a subject through in modern terms, has perpetuated viewpoints that are no longer as valid as they once were. Furthermore, the rehashing may also reiterate the same old attitudes. In books presenting the life stories of scientists, for instance, the first chapters almost invariably feature the homey touch: "The Smith family had little reason to suspect that their son was destined to be a great physicist."

This approach, which, incidentally, characterizes most of the "Immortals of Science" books, can probably be traced to the notion that people are more interesting than ideas, so that, inevitably, ideas are forced to take a secondary position in the writing framework. The young reader is not fooled. He senses the purpose of such devices, and the odds are that he will absorb what amounts to nothing less than a deep-seated distrust of ideas. A more honest and less hackneyed approach is to open the story with an account of those specific and fundamental phenomena that the scientist spent his life studying.

It so happens that two of the most creative projects of the past year or so are not addressed specifically to the twelve-and-over age group. The "Science Book-Labs" (Library of Science) are packaged units, each devoted to the study of an area such as growing plants or magnetism, and each consisting of carefully selected laboratory equipment, together with a book describing simple experiments and their significance. The units are designed for children eight to twelve years old, but more-advanced material in similar packages might appeal to older children. Another pioneering effort is the "Visual" series (Dell), in which artists and scientists collaborate to present in a new way the stories of anxiety, the heart, genetics, and astronomy. Although these are essentially adult-level books, they will certainly instruct and attract intelligent children.

Unfortunately, imaginative ventures are few and far between, because publishers seem to operate on the principle that people will buy again and again and again what they have bought before (although it is not obvious why the "give-'em-what-they-want" standards of commercial television should apply to educational books). The most flagrant example of this principle in action involves a subject that apparently cannot be done to death despite the persisting efforts of publishers: the exploration of space. Space books keep on coming like Japanese beetles, and most of them feature science "hardware"—rockets, launching pads, and interplanetary vehicles.

As our astronomy reviewer indicates in this survey, the boom in space books is directly related to widespread and high-pressure publicity, which fosters the venerable American tradition of glorifying gadgetry at the expense of basic science. The objective, of course,

is to impress the nation and the world with the fact that we are in the space race up to our necks.

There has been no major effort to give "equal time" to just as impressive work that is now under way in university laboratories. American investigators are among the international leaders in important new research on the biochemistry of heredity, stellar evolution, the workings of the brain, prehistory, advanced computers and artificial intelligence, embryology, and so on. But advances in these and other areas simply do not rate when it comes to planning large-scale campaigns in public education. It is no wonder that people are tempted to shy away from ideas and abstract concepts in science and that all forms of education suffer as a result.

Improving children's science books is not an isolated problem. We can hardly expect notable changes as long as publishers reflect the "hardware" attitude that dominates much current thinking about science and science education. But it would be encouraging if publishers exhibited the necessary initiative to put out books that place emphasis on basic research and the excitement of learning.

JOHN PFEIFFER

Anthropology

In assessing anthropology books for children, technique and presentation take precedent over subject matter. Whereas almost any subject that adds to our understanding of man can come under this general heading, poor technique or poor format can render the best material totally indigestible. We are, then, considering books that may be descriptively historical, formally archeological, or simply sociological. The subject matter ranges from ancient civilizations or primitive man, through the whole gamut of human history, to contemporary cultures. It is all infinitely absorbing and worth reading, and the important question to ask about any book in this field is: does it really instruct the child about his fellow human beings, about himself and his heritage?

This year's yield of anthropology books, a bare dozen, provides us with examples of the best and the worst in children's books. To dispose of one that annoyed me the most, without its necessarily being the worst, let us take Olga Hall-Quest's *With Stanley in Africa* (Dutton). The only passable thing about it is the type face. There is one messy map, and there are no other illustrations. The text is in an eyewitness style that would fool nobody, least of all a child, and the focal point is the overdone "Dr. Livingstone, I presume" incident.

The first half of the book leads up to Stanley's meeting with Livingstone, and the second half deals with his exploration of the Congo. To the author, Mr. Stanley is gallant and noble, whereas his own writings leave no doubt he was (if one is charitable) a homicidal egomaniac.

Because to the author Stanley is good, everyone who helps him is good, and the hard facts of history are distorted thereby. Slave traders appear, complete with slaves, as angels of mercy, and the unfortunate Africans once more emerge, in typical nineteenth-century style, as mere savages.

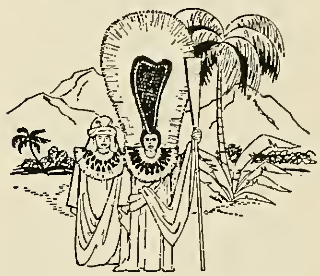
This to my mind is a bad and tiresome book because it distorts facts, perpetuates outworn myths, and attempts sensationalism. Any child worth his salt would get much more out of reading the first-hand accounts of Stanley himself.

Equally bad, in different ways, are two books from the Roy Publishers: *Ancient Egypt*, by R. R. Sellman, and *Exploring the Americas*, by L. F. Hobley. The print in each is faint and microscopic; the illustrations in the first might have been considered good fifty years ago; the overpowering list of contents in both is enough to dismay anyone. There is certainly nothing in either of these to attract adults or children, and their accuracy is questionable.

The Seven Cities of Cíbola, by Stephen Clissold (Clarkson Potter), is another book that is more historical than anthropological, but it is of a much higher standard. It deals with those events in the fifteenth and sixteenth centuries that led to the conquest of the seven cities to the northeast of Mexico. It is an exciting, well-told story, with the serious student in mind, and contains excellent, relevant illustrations and maps.

Leonard Cottrell, a prolific and somewhat controversial personage in the world of archeology, has come out with another book, *Land of the Two Rivers*. Printed, illustrated, and annotated with the elegance that typifies books of the World Publishing Company, this is a fascinating and stimulating work, vividly portraying history in the making — the very beginnings of what we know as civilization. I would personally question Mr. Cottrell's dismissal of "primitive" society and his implication that it does not possess the traits that characterize "civilization," whereas, in fact, the primitives often possess all the traits he lists for civilization—except for writing and the city itself.

Written on a higher academic level are two books by Robert C. Suggs, *Lords of the Blue Pacific* (New York Graphic Society), and *Modern Discoveries in Archaeology* (Crowell). The latter is a rather haphazard miscellany of recent archeological discoveries strung together on the mistaken assumption that the public is unaware that anything of impor-



From *Lords of the Blue Pacific*

tance has been discovered since the opening of the tomb of Tutankhamen. The miscellany includes, however, useful and interesting descriptions of modern techniques, such as radiocarbon dating and marine archeology.

Lords of the Blue Pacific is a much better book, having a more consistent thread—the origin of the peoples of Polynesia. It would have been immensely improved by better maps, an index, and a chronological table, but it is still a colorful account of a fascinating problem, and brings together many discoveries and ideas. It may not be quite as conclusive as either the publishers or the author claim, but is well worth reading.

Ancient China, by C. A. Burland (Dufour), is disappointing. The text occasionally goes into excellent detail, as in the description of pottery manufacture, yet elsewhere it virtually ignores important points, even in such a vital aspect of Chinese life as farming. In an attempt to make an index that will appeal to children, it is written down, and the result is a disastrous confusion of words, numbers, and irrelevant pictures. Some pictures, incidentally, are repeated three times in the book.

Far better are two books on American Indian life. *Indian Hunting*, by Robert Hofsinde (Morrow), is well written and well produced in bold type with illustrations that are relevant, informative, and attractive. It is a simple, factual book.

On these pages is NATURAL HISTORY's third annual survey of current science books written for children twelve or older. The departmental reviewers are all on the scientific staff of THE AMERICAN MUSEUM, and the introduction is by John Pfeiffer, an experienced free-lance science writer. The purpose of the survey is to attempt to offer some small measure of guidance to teachers and librarians who today are inundated with science books of widely varying levels of excellence. The editors also hope the reviews will be of help to gift-giving adults who may understandably be bewildered by the plethora of choices.

which tells of hunting techniques and how it feels to be a hunter. The final chapter avoids, a little too deliberately, perhaps, the real "end of the trail," and ignores problems that persist as a result of the end of hunting as a way of life.

However, *Chief Joseph*, by Russell Davis and Brent Ashabranner (McGraw-Hill), does deal with the end of the hunting era fairly and sympathetically. It would be difficult to write a bad book about Chief Joseph, but this struck me as being a particularly good one. It is the story of a peace-loving man driven against his will into a war that he knew would destroy him and his people. There are moments of real beauty in the book, and it adds to our understanding of the Indian and the tragedy that befell him.

I have kept two books until the end, because they are both outstanding in their own ways, and because they tell us about other peoples in other lands simply but effectively. *Little Calypsos*, by Lillian D. Krugman and Alice Jeanne Ludwig (Carl Van Roy), consists of songs and stories of the West Indies. The illustrated text gives the history of the land and people; the songs—with music and simple instructions on instrumentation—bring the text to life. This book is for younger children, perhaps under the guidance of a music teacher, but it is an idea that publishers might well develop for higher age-levels.

Another technique that results in a wonderfully vivid picture, this time of African life, is found in the exceptional new book by Peter Buckley, *Okolo of Nigeria* (Simon and Schuster), the sixth in a series. The technique is unusual because Mr. Buckley, in writing his books, travels to different lands with the sole intention of finding a child whose biography he can write for the benefit of all children. These are true life stories, and cannot be praised too highly.

The author is a fine writer and photographer, and his book is filled with pictures of Okolo at work and play. The traditions in his village seem odd at first, but as we begin to see with Okolo's eyes we learn that his life is not really so strange after all. For above all there is Okolo himself—a real boy growing up in Africa's largest newly independent nation. Something of the conflict between traditional and Western values emerges from the story of this simple village boy who wants to be a part of both worlds. It is a beautiful and sensitive account.

COLIN M. TURNBULL

Astronomy

THIS year's astronomy selections for young people contain a relatively larger proportion of "space science" books than did 1961. Lacking any other criterion, a buyer should feel fairly safe in acquiring a book on this subject if it is written by someone actually in the space program or a contributing industry. If the supply of authors among responsible authorities is limited (as it must be), at least some may be willing to referee manuscripts on these highly technical subjects—an inexpensive insurance for the publisher against a flood of reputation-damaging reviews.

Although not a book for pure pleasure reading, *Guide to Rockets, Missiles and Satellites*, by Homer E. Newell (Whittlesey House), is useful and authoritative for anyone, young or old. It was compiled by the Director of the Office of Space Sciences, National Aeronautics and Space Administration, and in a short introduction he defines and explains some of the terms frequently found in today's news—ramjets, air-to-surface missiles, guidance, control, sustainer, space craft, space vehicle to name just a few. The remainder of the book is an alphabetical listing of all known rockets, vehicles, and satellites, from Aeolus, an Australian sounding rocket, to Zuni, a Navy air-to-air missile. Most of the pages have photographs of some of the devices, often in action. The last eight pages contain a catalogue of all successful satellites and space probes to July 21, 1961—a total of sixty-four shots.

Dr. Newell is also the author of *Express to the Stars* (McGraw-Hill), a very readable discussion of rockets, rocketry, and the celestial mechanics needed to understand the problems of space flight. Still, it is non-technical enough to appeal to a child who lacks a working knowledge of higher mathematics. The illustrations are drawings, many copied from photographs. Anyone who wants to consult the original photos can do so in *Guide to Rockets, Missiles and Satellites.* It is a pleasure to read a good book by an outstanding expert.

In sharp contrast is *Space for Everyone*, by Philip S. Egan (Rand McNally). One-third of this paperback is devoted to an explanation of our view of the sky and the solar system from different locations on the earth's surface. Obviously, the author devotes so much space to the complex subject because a feeling for the spatial relations within the solar system is important. However, his technique of repeating a particular discussion from a different angle often results in confusion. Mr. Egan is apparently aware of this, because he closes the section with a tone of helplessness: "I cannot emphasize too strongly the importance of understanding the track of the Earth in the sky. When you just naturally understand that phenomenon, you will have the basic mental tool at hand that will allow you to realize the whole picture from that day . . . forward."

He next takes up the phases of the moon, a relatively simple topic, and gets it all wrong. Then he explains why planets and satellites have orbits and stay in them, and in so doing invokes the myth that centrifugal force balances the pull of gravity—a common error.

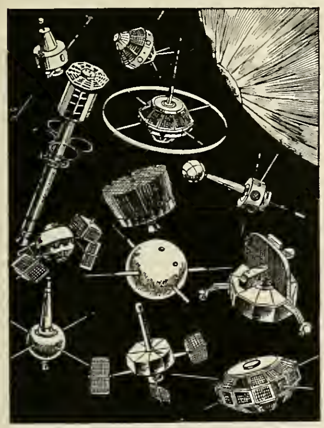
A passing mention of natural satellites, the origin of the solar system, and a discussion of comets, asteroids, and meteorites follows, and with this introduction to astronomy, the author launches into rocketry and a discussion of manned and unmanned satellites.

It is not clear for what age level this work is intended; an occasional grammatical construction or foreign phrase appears too difficult for the average primary student, and the format is too juvenile for an adult. *Space for Everyone* seems to be a book for no one.

Life Beyond Our Planet, by Dan Q. Posin (McGraw-Hill), is dedicated "To the Inhabitants of Other Worlds." This is a timely book on a subject that has attracted attention for centuries. Dr. Posin, a physics professor, discusses the recent effort to detect radio signals that may have been transmitted from nearby stars. This effort, which naturally received much publicity, was the first in man's history that had any reasonable chance of success. To illustrate the dif-

ficulties in the problem, the author briefly describes the scale of distances involved, and then shows how two intelligent communities might begin to establish a common language by exchanging universal ideas about numbers and geometry. Following a simplified discussion of the technical aspects of the equipment to be used, the author describes the nature of the galaxy and the stars in it and in our immediate neighborhood. Naturally, the solar system receives a great deal of attention, as does the possibility of life chemistries based on elements other than carbon.

Although Dr. Posin's writing style is not so skillfully dramatic as that of some other professors, the book contains much provocative material. One would expect, however, that a trained and practicing scientist would write with scientific accuracy. Yet, among other errors, he perpetuates the myth that Martian satellites may be artificial. Granted, there are problems about these satellites that such an interpretation would simplify. However, the determination of their very low density, which is crucial to such an interpretation, was based on an old paper that has been repudiated within the last two or three years. Dr. Posin mentions the possibility of landing on one of the moons of Jupiter, but he fails to make the very exciting



From *Express to the Stars*

point that a traveler must choose the particular moon with care, or he might find himself within the vast and energetic Van Allen radiation belt, which surrounds the planet. If another edition of this book is contemplated, it is to be hoped that an astronomer will be asked to read the revised version before it is presented to the public.

The universe is large and there are infinite ways to write about it. Dr. Heinz Haber has selected a combination of per-

sonally meaningful topics and has made them interesting in *Stars, Men and Atoms* (Golden Press). Each chapter can be read with enjoyment as a separate entity, because each is informative and dramatic in itself. Two chapters deal with the history and development of our ideas about logic, mathematics, atoms, and space. Another describes the earth in terms of a model, developed as one might see it on a screen (although the reader may occasionally mistake the model for the real earth). A chapter is devoted to the sun and one to the history of planetary system studies. Artificial satellites and a collection of diverse thoughts on propagation of radio waves, space travel, weather control, and related subjects are covered in two chapters. Two others discuss general concepts of the possibilities of life in the solar system and other parts of the universe. One chapter, a clear, dramatic explanation of carbon-14 dating, is unusual in a book primarily about astronomy. In the form of a scenario, it describes the trials and tribulations of our hero, a particular atom of the radioactive isotope of carbon, from creation to final breakdown in a laboratory. The last chapter speculates on whether or not the universe is infinite.

A few dissonances occur, but they are hardly important to the book as a whole. The twenty-pound meteoroid would not completely vaporize, for instance. Some hasty editing seems apparent in the relation of chapter titles to content, but this is not a serious drawback to Dr. Haber's intelligent, interesting, and easy-to-read book.

Walter Shepherd has been described in his native England as "*the* expert in scientific explanation." His book, *The Universe* (Messner), cannot bear witness to the validity of such a statement. Hardly a page is free from inaccuracy or misunderstanding. Several notably wrong ideas and a few real errors contribute to the hierarchy of misstatement. "After a week or so, the moon grows to its first 'half,' which astronomers call the 'first quarter' because even the full moon is, of course, only the half that faces us. It then passes through a three-quarter, or 'gibbous,' phase, to reach full moon just a fortnight after new moon." It is apparent that Mr. Shepherd does not know when third quarter occurs.

"Also, the moon does always turn the same face towards the earth, and—as was shown by the Russian satellite Lunik III in 1959—the moon is certainly egg-shaped and bulges towards the earth." Lunik III showed nothing of the sort. The peculiar shape was caused by the illumination of the moon, which made it appear gibbous to Lunik cameras.

While discussing galaxies, Mr. Shepherd lists a few forms from Hubble's morphological classification, and remarks: "Reading this list downwards, we see the galaxies passing from youth to old age." No one is ready to commit himself on the evolution of galaxies, for there are still too many imponderables in this highly complex subject.

These random examples do not exhaust the supply of mistakes, but should demonstrate that simple and complex subjects are treated with equality.

K. L. Franklin

Botany and Ecology

Last year the principal criticism of books on botany and ecology lay in an abundance of technical errors that rendered them practically valueless, despite good basic themes. Now, while publishers obviously cannot always wait for outstanding authorities in the several disciplines to write popular books, their lay writers would be well advised to seek assistance from a scientist when dealing with unfamiliar material, and should utilize that help in all phases of the book's development. Too frequently, however, an author is hired to turn out a manuscript within a time limit, and the publisher appears to believe that his obligation is only to manufacture and market an attractive product—with or without errors. This moral failing is as obvious in this year's crop of books as it was in those examined last year.

Among the 1962 ecological volumes, the special childen's edition of *The Wonders of Life on Earth* (Golden Press), from the original edition by the editors of *Life* and Lincoln Barnett, is the most impressive, with striking color illustrations on most of its 216 pages. The first chapters present a historical account of Darwin's development of his theory of evolution, illustrated with excellent photographs and drawings of the Galápagos Islands and some of the animals whose ancestors evoked such wonder in the young scientist during the voyage of the *Beagle*. The next chapters describe various aspects of evolution, including, among other subjects, mimicry and social behavior, migration, courtship behavior, and the ways of primitive peoples. The last chapters discuss hereditary mechanisms, case histories of man's influence on animal heredity through breeding, and a capsule review of the evidence of human evolution and of the development of major animal groups.

Although *The Wonders of Life on Earth* is an excellent contribution to the list of biology books available to younger readers, it is unfortunate that the text was not subjected to a more critical scientific review before publication. Most unfortunate in a book on this subject is the suggestion that animals are able to direct their own evolution. For example, a moth is said to have "found a way to take advantage of the sun," when actu-

ally an evolved peculiarity in wing position is described.

Another attractive book, crammed with illustrations in color, is *The Golden Book of Gardening*, by Frances Giannoni (Golden Press). This is a thorough résumé of outdoor and indoor home-gardening methods, and is an excellent guide for junior high school or high school students who wish to raise their own flowers or vegetables. Again, however, the text obviously was not reviewed by a competent scientist and its quality is damaged seriously by anthropomorphism and factual errors that will be apparent even to a beginning botany student. For example, photosynthesis is said to "turn . . . carbon dioxide into starch," and that "most plants later turn this starch into sugar." Repeatedly, plants are said to obtain food from the soil. Fortunately, most of these errors are confined to the first few pages of the book. Later sections give directions for the planting and care of various ornamental plants and vegetables.

From *From the Eagle's Wing*

Three volumes in this year's group are devoted to the fascinating profession of the forester. The most thorough, accurate, and up-to-date is *Logging, the Story of an Industry*, a Sunset Junior Book (Lane) by Arthur S. Taylor, Jack Sutton, and Bart Benedict. Accompanied by excellent color and black-and-white sketches, the book describes old and new techniques of harvesting, forest protection, and forest management in the western conifer forest.

Rain Forest, by Bill Brown (Coward-McCann), takes up the Pacific Northwest forest region. There is little about the forest as such, and perhaps that is fortunate, for this author lapses into the use of teleology when he treats basic natural history. The most absorbing chapter of the book tells of the preservation of the magnificent Bull Creek stand of coast redwoods and the subsequent threat to the stand caused by improper logging on higher sections of the watershed. Other chapters describe the tree farm system, review the history of logging and conservation action in the region, present a rather trite description of action during a forest fire, discuss superior hybrid trees, proposed new harvesting techniques, and products that may be derived from wood. The book is illustrated with a number of fine black-and-white photographs, well integrated with the text.

In contrast, the third book on forestry, *Science and the Forester*, by Leslie Wolff (Criterion), with the American edition prepared by Iris Vinton, is a thoroughly British treatment spiced with a number of photographs of American forest scenes that are largely unrelated to the text. It is a story of how a young man's interest in forestry is stimulated, of his subsequent training, and of his duties as an English forester. As realistic as it may be for the English setting, and despite the American illustrations, the book gives an unreal picture of the life of a professional forester in this country.

A volume that should be welcomed by young American naturalists is Peter Thomson's *Wonders of our National Parks* (Dodd, Mead), which brings several of these wonders within its covers in twenty-one fine black-and-white photos. After a short chapter concerning the history of the National Park Service and a general account of the duties of its field personnel, Mr. Thomson presents succinct descriptions of Yellowstone, Hawaii, Crater Lake, Sequoia, Everglades, Grand Canyon, Zion, Bryce Canyon, Mesa Verde, Carlsbad Caverns, Mammoth Cave, Mount McKinley, Mount Rainier, and Yosemite National Parks.

This Crowded Planet, by Margaret O. Hyde (Whittlesey House), is intended to acquaint the reader with the serious problems civilization faces as a result of the rapid increase of the human population, the increasing demand for space and energy, and the overwhelming drain on natural resources by modern industry and transportation. The book reviews possible answers to these problems, from technological advances in mining and refining to desalinization of water, sea-farming and sea-mining, nuclear energy, and space exploration. Mrs. Hyde's goal is admirable and its concept vital, but the book is a hodgepodge of loosely related facts and "Ripleyisms" that grow dull by virtue of their abundance. Many of the topics are covered so superficially that there is little hope the average young reader will gain a genuine understanding of the basic problems.

Four of this year's books are readable,

authentic. "dramatized" biographies of famous naturalists. *Trails of His Own*, by Adrienne Grossman and Valerie Beardwood (Longmans. Green), and *From the Eagle's Wing*, by Hildegarde H. Swift (Morrow), tell of the unusual life of John Muir, a Scotch lad who became one of the most effective leaders in the American conservation movement and played a central role in the establishment of our national park and national forest systems. Although both of these biographies are well written, *From the Eagle's Wing* exhibits more careful and extensive research.

Plant Explorer, by Beryl Williams and Samuel Epstein (Messner), is the biography of David Fairchild, the pioneering botanist of the Department of Agriculture who was responsible for introducing many new crops to the United States. This is a well-written, intimate story of a world-roving naturalist, but more important, it contains many of the words of suggestion and criticism offered to the youthful Fairchild by several world-renowned botanists who were members or close friends of his family. These are equally pertinent today, and the modern young naturalist will benefit from them as much as did Fairchild.

Another biography, *Beloved Botanist*, by Adrien Stoutenburg and Laura N. Baker (Scribners), is the story of the life of Linnaeus, the eighteenth-century Swedish naturalist who formulated the binomial system of biological names and the sexual system of classification. Of the four biographies, this seemed to me the most overdramatized and least informative. It is well written, with smoothly flowing dialogue, but it lacks insight into the meaning of Linnaeus' contributions to science; it fails to give the proper interpretation of his work from a modern standpoint; and it does not communicate a feeling of real personal acquaintance with the subject.

The last two books are related in that both offer an opportunity for personal experimentation. *Anyone Can Live Off the Land* (Longmans, Green), is by James Ralph Johnson, a Marine Corps major who has briefed pilots on survival in Korea, has attended survival schools in Japan and England, and has been a Boy Scout field executive. His book is a collection of instructions for finding food, building shelters, cooking wild game, finding one's way, and avoiding toxic plants and dangerous animals in the outdoors. The novice camper will find many helpful suggestions, and the experienced one will discover a number of new ideas to test on his next trip. Some of the material included is of dubious quality, in my estimation, but I have yet to give them fair field tests. The one section that should be considered unreliable is that on wilderness first aid. Anyone planning a hiking or camping trip into a secluded area should be sure to take along proper first-aid equipment and professional medical instructions.

Morris Goran's *Experimental Biology for Boys* (Rider) is a formal presentation of simple experiments that can be carried out in an inexpensively equipped home laboratory, and that should result in a better understanding of basic biological principles. However, the book provides insufficient information for the interpretation of many of the experiments. This could be remedied by supplementary reading in a local library or in standard high school biology textbooks. Inexcusably, the text contains anthropomorphisms and teleological statements that detract from its scientific authority. Furthermore, the term "life" is confusingly used in place of "living organism," and the experiments, while individually interesting, do not progress logically from one to the next.

Jack McCormick

Geography, Geology and Paleontology

Books on geography, geology, and paleontology examined this year show a definite increase in quality over those reviewed a year ago. Of the sixteen books mentioned below, eight are rated as excellent, five as fair to good, and only three as downright poor. Books on glaciers, icebergs, and the Antarctic are extraordinarily popular, comprising nearly one-third of the selection.

Geography, a volume in the Doubleday Pictorial Library, lists Gordon Manley, Gerald Barry, J. Bronowski, James Fisher, and Julian Huxley as the editorial board. It is often said that nothing original comes from a committee, and upon first reading the preface to this volume, one is tempted to conclude that editorial offices, like admiralties, have followed the dismal upward spiral of Parkinsonian growth.

Yet, astonishingly, a team of eleven writers has been not merely productive, but creative. The purpose of their enterprise, as stated in the preface, deserves to be quoted here if only because they have managed to fulfill it.

"*Geography* is the third volume in a comprehensive survey of human knowledge intended for the family.

"This is not an alphabetic volume. It is . . . systematic. But with its specially detailed glossary, statistical guide and index, it has not only the advantages of a conventional alphabetic encyclopedia, but others far deeper besides.

". . . we believe that we have found a logical approach. The first half of this

book starts historically, with those first geographers — the explorers — and broadens . . . into an analysis of the whole face of the earth, from the physical, human and economic points of view.

"It is the second half that concentrates on *regional* geography, at a stage when the reader has already grasped deep principles. Each chapter in this half deals with a region's physical features; next with its economic resources; then with its peoples and their ways of life; and finally with the region's position in world affairs."

The text is a delight to read: crisp, informative, and tasteful. Diagrams and photographs have been drawn and selected with great care and imagination. Color maps of the continents are breathtaking. Important concepts are brought into focus sharply by the apt and often witty selection of illustrations. This is a distinguished book for the entire family.

Upon hearing the name Alexander von Humboldt, most scientists and many laymen think only of the oceanic current that was named for him. Historically oriented books of or about science commonly contain brief references to his work and then pass on to other matters. That the name von Humboldt should fall into semioblivion is remarkable when one considers the scope, volume, and quality of his work. Beginning in 1796 with his first published book (on galvanism), he worked tirelessly and originally in a staggering variety of fields, publishing voluminously in all of them until the middle of the nineteenth century. In anthropology, he gave the world its first glimpse of Aztec, Inca, and Mayan cultures, and made the first interpretation of the Aztec calendar. In astronomy, he worked with Herschel on planetary movements. He was the first to establish the geographic distribution of plants, and the first to evaluate the influence of climate and altitude on their growth. He laid the foundations of the science of geography, made pioneer researches on terrestrial magnetism, and was first to study and identify circum-oceanic volcanic chains. Although he never visited the west coast of South America, by studying climatic patterns he correctly deduced the existence of the major current that now bears his name.

With all of this, and much more, to his credit, we may wonder why Humboldt's name is not better known today. The answer is twofold, according to Val Gendron, author of *The Dragon Tree* (Longmans, Green). Humboldt could not bring himself to blue-pencil his writings, and as a result his numerous books are enormous, little-read tomes in the rare book rooms of libraries. He also had the misfortune to be followed on stage by Charles Darwin.

In this outstanding biography, the author has dusted off von Humboldt's work, made judicious extracts from it, and presented the man and the scientist to us for inspection. Readers will profit from and enjoy this book, and learn of science by observing the education and growth of a true pioneer.

Volcanoes in Action, by Lynn and Gray Poole (McGraw-Hill), is an excellent, well-illustrated, and accurate book about volcanic phenomena. An adequate coverage is given to scientific theory, but the main stress is on a description of volcanoes and volcanism. The human interest factor is maintained tastefully, and at a high level; the young reader's attention will not falter. Classic events such as the birth of the volcano Paricutín, witnessed by young Pedro Pulido in central Mexico on February 20, 1943, are well told, as are less-known stories.

From *Volcanoes in Action*

Not quite up to the standard of the Pooles' work is *Volcano!*, by Walter Buehr (Morrow)—a good, short, accurate, and interesting book about volcanoes. More care should have been taken with illustrations, and for the intended age group the theoretical matter is too abstract. The description of the disaster in Martinique when Mt. Pelée exploded in 1802, is an exciting story well told in the best Walter Lord manner. The accompanying picture of the fire cloud is appropriately horrifying.

Volcanoes and Earthquakes, by Robert Irving (Knopf), is a short, undistinguished book, marred by poor illustrations. The section headings are often unnecessarily sensational: "Funeral of a Town": "A Volcano's Bad Breath."

A spate of books published this year covers various aspects of glaciers, glaciology, and the geology and exploration of the Antarctic. *Antarctic Adventure* (Dutton), by Sir Vivian Fuchs, leader of the 1955-58 Commonwealth Trans-Antarctic Expedition, heads the list. It is, naturally, authoritative. It is also well illustrated with photographs, floor plans of remote habitations, and other details appealing to boys. The text is well done, and breathes adventure.

Another excellent, authoritative book for the older child is *Defrosting Antarctic Secrets*, by Henry S. Francis, Jr. and Philip M. Smith (Coward-McCann). The text is directed to young men, perhaps a bit too pointedly at times, but many readers will wish they were Antarctic scientists. Details of life in camp are combined with a good summary of the scientific results achieved to date. Questions as to the depth of Antarctic ice and the age of the snow cover are treated with accuracy and style. A fascinating photograph of the interior of Scott's camp when it was opened forty-seven years after his death is included.

From *The Making of Man*

McMurdo, Antarctica, by William Bixby (McKay), is a rather good book for the older reader. It is primarily a history of Antarctic exploration in the McMurdo Sound area. Scientific matters are played down, but as an adventure story it is well done. One unfortunate feature is the poor quality of maps and the lack of illustrations.

Two fine books for the younger age group are *Danger! Icebergs Ahead!*, by Lynn and Gray Poole (Random House), and *The First Book of Glaciers*, by Rebecca B. Marcus (Watts). The first discusses a limited but fascinating subject. The illustrations are arresting; the text is clear and accurate. The second, too, is well written, informative, and accurate.

Boris Arnov, Jr. and Helen Mindlin had a clever idea in basing a book on exploring the earth with a Jules Verne type of underground vehicle. Unfortunately, *Inside Our Earth* (Bobbs Merrill) is an inferior product. In addition to some glaring errors (the explorers come upon underground caverns and streams five miles down!), the interludes between adventures are used to strike off on too-varied and often inappropriate short scientific explanations.

In another area, *Ancient Animals of America*, by W. W. Robinson (Ritchie), is an unsatisfactory attempt to develop interest in fossil monsters. The text is jumpy and filled with disconnected ideas and descriptions. No attempt is made to view underlying processes of interest and importance. Inexplicably, the illustrations are all done in green ink, creating an unnecessarily macabre mood.

On a considerably higher level is *Prehistoric Life on Earth*, by Kai Petersen (Dutton)—a good, sound, nicely illustrated book. It contains a careful statement of modern ideas on the process of evolution and a panorama of the history of life as shown by the fossil record. The latter portion, however, is too detailed, and would have been more effective if it had been pruned.

An excellent, accurate, beautifully illustrated book is *The Making of Man*, by I. W. Cornwall and M. Maitland Howard (Dutton), whose main emphasis is on the physical anthropology of fossil men. The text is meaty with facts; speculation is minimized.

Miracle Metals, by Ellsworth Newcomb and Hugh Kenny (Putnam), should serve primarily as a reference for students who are writing essays on metals and metallurgy. The early part of the book is written down embarrassingly, while the latter part contains technical details of considerable complexity, creating an imbalance in the whole.

As a theme on which to hang a book, *Carbon-14*, by Lynn and Gray Poole (Whittlesey House), runs rather thin. Although ingenious and useful, it falls somewhat short of the mark and would be improved if cut by half. Subjects such as oil-finding, for instance, are dragged in as space-fillers. The book explains the carbon-14 dating method, which is of such importance in many historical sciences, and that portion concerning descriptions of the method itself and its various applications are well done.

JOHN IMBRIE

Zoology

ONE trend in biological education is toward presentation of concepts and facts—formerly reserved for the high school level and beyond—to the younger students, who are now offered varied selections in many areas, which in previous years they could not hope to explore until well into their teens. However, there are many facets of biology that cannot be truly understood until a student has acquired a broad background and until he is sufficiently matured to place ideas in perspective. Thus, the burden of presenting advanced concepts rests upon the author, who must give ample background, place the concepts in perspective, choose his subject matter wisely and well, and separate the important from the unimportant. Diluted versions of books written for older children are not always satisfactory, since simplification of language does not necessarily result in clarification of ideas. Moreover, the author must see to it that there is a generous and judicious use of visual aids, especially

important in biology. This does not always require more pictures, but can be handled by better and more cohesive interweaving of text and illustration.

Of the fifteen books reviewed, two deal with contemporary research, and both authors are to be admired for tackling the challenge of presenting findings being made in laboratories today. *The Language of Animals*, by Millicent E. Selsam (Morrow), is a well-written, factual story about how animals communicate by sound, scent, and visual signals, singly or in combinations. The author has taken great care not to treat her animals as humans, and she points out that animal communication is not language in our sense. Mrs. Selsam discusses fish behavior, frog calls and mating, vibrations and snake charmers, bird songs and courtship, and the sounds of mammals. The book ends with a description of dancing bees and the glowing light messages of fireflies. It is unfortunate that a book of this quality is marred by a low illustration budget.

The second book is a noble and brilliant attempt to explain DNA. This is a fundamental component of all cells; its influences pervade the body and shape the future of animals and of plants, and it is important for all of us to understand something of its nature and its possibilities. Within the pages of *Life's Key—DNA*, by Carleen M. Hutchins (Coward-McCann), one can find recent research evidence from here and abroad about the structure, chemical components, and location of DNA, of DNA in heredity and in protein synthesis. The illustrations, mainly photographs and diagrams, are magnificent. There are well-chosen electron micrographs of DNA molecules, some of which are magnified 300,000 times, and there are explicit line drawings of the possible structure of the molecule. And, in order to make sure of comprehension, the author tells how to construct a do-it-yourself, take-apart model of DNA.

In spite of its excellence, the book will present problems to readers without some smattering of biochemistry and its terminology. Nonetheless, the author deserves an accolade for writing about this topical and exciting area of science that is changing so rapidly her book may be out of date overnight. If so, I hope another one will be forthcoming.

Among the remaining books, only four can be rated excellent on the basis of clearly written, accurate, and up-to-date textual material accompanied by illustrations of high quality. These are scattered through the three main themes of general biology, zoology, and marine biology. The other books are uneven. They have good texts with poorly chosen or poorly drawn illustrations; they are well illustrated with only fair texts; or they are poor in both categories.

There are several entries on general biology this year. *The Science of Life*, by Louis and Lois Darling (World), is a splendid example of excellence. The Darlings know how to prepare a book and are wise in the ways of selecting pertinent and important concepts. Written for the high school student, it is a comprehensive survey of biological principles with examples, found in a variety of animals, demonstrating these principles. Information about the biosphere, cells and metabolism, the organization of living systems, reproduction, genetics, evolution, and ecology is up to date, accurate, and clearly expounded. The illustrations are drawn by the authors' talented hands; in addition to being beautiful, they are well labeled and intelligible. I recommend the book highly.

For the younger reader, *The Giant Golden Book of Biology*, by Rose Wyler and Gerald Ames (Golden Press), is quite charmingly illustrated. The attractiveness and profusion of stylized animals, plants, and molecules make the pages pleasurable to peruse. Even the young non-reader will be enchanted with the pictures. Its biological coverage is broad and comprehensive. According to the authors, they were guided in their selection of material by the reports of the Committee on Education of the AIBS (American Institute of Biological Sciences). They discuss, to name but a few topics, the chemistry of plant cells, photosynthesis, the chemistry of animal cells, DNA, genetics, behavior, evolution, physiology, the systems of the body, the origins of life, and the problems of living in space—which I am sure a number of their readers will do in time. The subjects are clearly presented, the writing is simple, and the contents are accurate. The book is indexed, and has a preface by George Wald, the eminent biologist at Harvard University. All in all, a delightful book.

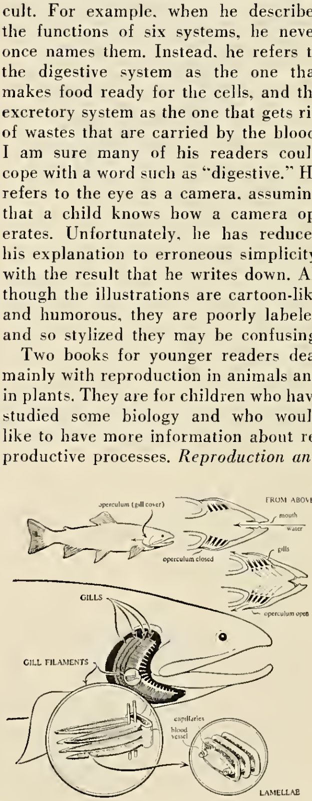
When I picked up Ethel Hanauer's book, *Biology for Children* (Sterling), I expected to find a biological text. Instead, it turned out to be a series of experiments with plants and animals that, with the exception of a microscope, require only easy-to-find equipment. It is the kind of book that should be used with a regular biological text, since it contains relatively little on biological principles. There are diluted versions of experiments found in first-year college courses on molds, stems, roots, leaves, flowers, physiology of plants, how to collect leaves and ferns, and so on. Approximately two-thirds of the book is devoted to plants, the other third to animals. This is just as well, as the animal section is the poorer of the two. The illustrations of the experimental material are evidently executed by someone who does not know how to draw, and they are unlabeled. The print in the

index is unreadably tiny. However, the ideas for simple experiments will be useful in the classroom and, if parents are indulgent, in the home.

Three other books on biology deal with more specific subjects. One for the younger set, *The Wonder That is You*, by Charles Gramet (Abelard-Schuman), is a simply written and easy-to-read book about human biology. Its makeup is unusual, composed of blue, white, and yellow pages that alternate non-sequentially, so that while the appearance of the book is gay, it is also distracting.

The body's systems are compared to mechanical structures, and the body is treated as an engine. The author carefully tries to avoid overwhelming his reader with words he considers too difficult. For example, when he describes the functions of six systems, he never once names them. Instead, he refers to the digestive system as the one that makes food ready for the cells, and the excretory system as the one that gets rid of wastes that are carried by the blood. I am sure many of his readers could cope with a word such as "digestive." He refers to the eye as a camera, assuming that a child knows how a camera operates. Unfortunately, he has reduced his explanation to erroneous simplicity, with the result that he writes down. Although the illustrations are cartoon-like and humorous, they are poorly labeled and so stylized they may be confusing.

Two books for younger readers deal mainly with reproduction in animals and in plants. They are for children who have studied some biology and who would like to have more information about reproductive processes. *Reproduction and*



From *The Science of Life*

Sex in Animal Life (Abelard-Schuman) is a second entry by Charles Gramet. He covers asexual reproduction (cell division, budding, regeneration of parts) and sexual reproduction; he describes such various facets of reproduction as breeding seasons, mate selection, courtship displays, and parental care, and modestly describes human courtship and sexual behavior.

Although there are no glaring errors in the book, there is insufficient detail in certain explanations, and a subtle juxtaposition of some phrases that might give rise to serious misunderstandings. Too, the author has pat answers as to why some girls are tomboys and some boys are effeminate—it's all hormones—and I am certain current researchers will be pleased to know that Mr. Gramet has solved a thorny problem for them. The inclusion of this kind of material does not indicate the wisest of choices. The illustrations, photographs, and drawings are easily overlooked, and do not enhance the text.

How Life Goes On, by Irving Zeichner (Prentice-Hall), is devoted to a survey of the salient similarities in animals and plants. Zeichner starts out with asexual reproduction (cell division, budding, sporulation, regeneration of parts from cuttings). He describes alternation of generation in ferns, in which one generation reproduces sexually and the next reproduces asexually. He covers seeds, eggs, sperm, and reproduction in fish, Amphibia, birds, and mammals. Nothing is treated in depth, and the book contains its share of inaccuracies. For example, a child born after four months gestation might "survive." Not so.

It is clearly written, and the text is easy to follow. The illustrations are poor and useless; they neither extend nor clarify the text.

Four books on special topics in zoology are reviewed in descending order of merit. Far in the lead is *Big Cats*, the excellent Junior Science Book by Robert S. Lemmon (Garrard). Attractive, scientifically accurate, and beautifully illustrated in tones of gold, it covers the biology, food, habits, methods of communication, and senses of big cats, and suggests a number of observations—such as pupil size in dark and light—that a child can make on his or her own smaller feline. There is history, too, of domestication and of the "godlike" Egyptian cats. One of the book's drawbacks is that, unfortunately, it will make many children want to have a big cat as a pet.

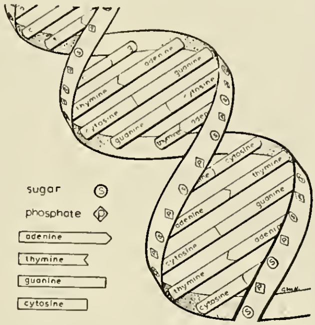
American Animals, by Dorothy Knight, with photographs by Leonard Lee Rue III (Arco), is a word and picture guide that contains descriptions of forty-eight mammals a child might find around his house, in the park, in woods, or in the mountains. Mr. Rue presents some good photographs of raccoons, muskrats, wolves, fawns, bears, beavers, and so on, and each photograph is accompanied by a one-page description of the animal's habits, including food and care of young. It is not a unique book, as it resembles many publications that attempt encyclopedic presentation of a special subject. The system of chap-

ter headings is uneven; for example, the author starts out with food habits as a system for grouping and then shifts to anatomical characteristics. In addition, there is a tendency toward loose use of the term "family." Family, in zoological classification, has a specific meaning and it cannot be interchanged with Order. The author frequently mixes the two.

The next two books add to the already vast clutter of mediocrity presented to children. *Nature Adventures*, by C. B. Colby (Dial), is a diffuse collection of sixty-one mammal stories, obviously first written for some newspaper or magazine column, that have been bound in one cover without a unifying thread, except that of the binding. There are chapters on horns and antlers, paws and tracks, hoofed mammals, carnivores, rodents, and advice on what to do if a skunk falls into your cellar. Taken one at a time, these stories might be interesting: as a collection, they are monotonous. The author's illustrations are good line drawings, except for those in the first several chapters, where the labeling is hard to follow. The index is merely an alphabetical rearrangement of the table of contents and is of little help.

From Scales to Fancy Feathers, by Iona Seibert Hiser (Rand McNally), is a bird watcher's experiences in the Southwest. It is chatty, banal, prosy, and dull. The illustrations are ordinary. Although the title implies an evolutionary study, the first chapter tells only a little of birds' reptilian ancestry, which is probably just as well, for Mrs. Hiser's knowledge of evolution is pre-Darwinian. She states that "when muscles are not used they become very weak—so if generation after generation of any kind of animal—whether bird, man or some other creature does not use certain muscles, they at last become useless." This concept, Mrs. Hiser, has not been accepted for many decades. For anyone interested in reading it, the book is a highly personalized account of the author's contact with a vast number of birds, many of which visited her terrace. It has an index, a suggested reading list, and the location of bird sanctuaries.

We have but a few entries this year on oceanography and marine biology. One is a joy to look upon. It is *The Book of Sea Shells*, by Michael H. Bevans (Doubleday). His illustrations are exceptionally well drawn, accurate in dimension and in color. The author does not pretend that the book is more than an introduction to shell collecting, and he identifies only 200 of the thousands of mollusks. A few samples of each of the five major groups are described and illustrated, and the author lists their geographic ranges, foods, size limitations, and their commercial uses, if any, both past and present. Unfortunately, the large size of the book makes it clumsy to carry along on shell collecting expeditions, but it is a wonderful reference for the end of a day. This past summer we spent many hours collecting shells on tropical beaches in the Caribbean, and found every shell type within the pages of this beautiful book. I strongly recommend it to novice collectors of all ages.



From *Life's Key—DNA*

In sharp contrast to the above example of the book craft, we have *Ocean Harvest*, by Helen Wolff Vogel and Mary L. Caruso (Knopf). It tells about the ocean as a harvesting ground, and surveys whale hunting, oyster farming, oil drilling, algae gathering, water distillation, and mineral mining. It is not a good book, and contains many inaccuracies, one of which is a particular beauty. The authors state that in order to use an aqualung, "you must put on goggles or a face mask to protect your eyes from the stinging salt water." I have always thought that masks are worn in order to prevent vision from blurring severely. I think the authors have never been to sea, but have explored the ocean only from their library tables.

Although not about the sea itself, *Exploring the Seacoast*, by John and Jane G. Perry (Whittlesey House), is a fine introduction to the study of the sea, and the title describes its contents. It is a chatty narrative about a family's adventures with flora and fauna on the beaches of the eastern United States, particularly the barrier islands. The writing is charming and the book is a perfect one to read before exploring a sandy ocean beach.

EVELYN SHAW

Free reprints of the 1962 Christmas book survey are available to librarians and teachers who write us on their official letterhead. The flood of 1961 requests, however, forces us to ask that stamped, self-addressed envelopes be enclosed. Address: Reviews, NATURAL HISTORY, 79th Street and Central Park West, New York 24, N.Y. Others who wish copies may obtain them at cost—20¢ a piece.

Hunters of Savoonga

Eskimo economy is based on walrus herds

By Edmund Carpenter

St. Lawrence Island is a storm-lashed rock in Bering Strait. Temperatures average far below freezing and never exceed 65 degrees. Winds of up to 100 mph blow most of the snow from the land. Snow or rain occurs nearly every day; the sky is rarely clear. It is a land that possesses only one asset: walrus.

Local Eskimos are completely dependent upon them. In the winter of 1879, hunters engaged in a prolonged debauch with liquor acquired from whalers missed the walrus herds going by on the November ice. The following summer John Muir, the famous naturalist, who was then on the U.S. revenue cutter *Corwin*, witnessed the appalling result:

"We found twelve desolate huts close to the beach with about two hundred skeletons in them or strewn about on the rocks and rubbish heaps within a few yards of the doors. The scene was indescribably ghastly and desolate, though laid in a country purified by frost as by fire. Gulls, plovers, and ducks were swimming and flying about in happy life, the pure salt sea was dashing white against the shore, the blooming tundra swept back to the snow-clad volcanoes, and the wide azure sky bent kindly over all—nature intensely fresh and sweet, the village lying in the foulest and most glaring death. The shrunken bodies, with rotting furs on them, or white, bleaching skeletons, picked bare by the crows, were lying mixed with kitchen-midden rubbish where they had been cast out by surviving relatives while they yet had strength to carry them."

Male walrus sleep in the summer sun. Rivalry, which seems non-existent here, becomes evident when females arrive.

Over two-thirds of the island's estimated population of 1,500 had died. The total absence of children's bodies led Muir's companion, Edward Nelson, to the conclusion that they had been eaten. In the brutal realities of this land, children who could not survive if left to themselves had to be sacrificed to save adults who could preserve skills essential to Arctic survival.

There was ample food here, however, for alert hunters, and the survivors held their own. Bering Strait funnels an incredible quantity of sea life in and out of the Chukchi Sea—walrus, seal, whale, sea lion, char, salmon, herring, and tomcod. St. Lawrence Island stands dead center in the mouth of the Strait, and here, along the shores and in the bays, the islanders took their tithe from the sea.

Traditionally, walrus were killed with harpoons and lances. When the sea currents were stilled by January weather, the hunter stalked the sea ice along the northern side of the island, miles from his village, armed with a harpoon, coiled walrus-hide line, lance, ice-tester, and knife. His dogs helped him locate fresh breathing holes, and beside one of these he waited, sometimes for hours, while his dogs slept, their heads hidden from the cutting wind. The walrus first nudged the thin ice film aside, then came up for a deep breath of air. Like a coiled spring, the hunter went up on his toes, drove the harpoon deep into the animal's nose and raced back, playing out forty to fifty feet of line. To escape, the walrus had to turn downward, and this brief delay gave the hunter time to jab the bottom of his sharp-pointed harpoon shaft through a loop in the end of the line and down into the ice. Then came the sudden jolt when the

Dark bodies of resting walrus almost cover an ice fragment in Bering Strait. Eskimos use their homemade boats to stalk the groups through the drift ice.

VICIOUS when provoked, these animals are plunging off the ice to attack the boat in which photographer is riding. Walrus often capsize boats or rip hulls.

line snapped taut, anchoring the harpoon head firmly in the walrus. Both hunter and hunted strained, the hunter aided by his fastened line, the walrus trapped by his need for air. If the line slackened momentarily, the hunter gouged two holes about a foot apart in the ice and laced the line through them to make them fast. Or he tied the end of the line around an upright cake. Either method freed him to lance the animal when it surfaced for air.

There was no escape for the walrus: it had to have air—which it could get only where death waited. An infuriated beast might climb up on the ice and attack the hunter. Or a hunter might get a foot tangled in the line and be dragged beneath the ice (hence the knife, to cut himself loose). Almost always the hunter won.

With a method still used, the carcass was hauled out on the ice with a block and tackle made by fastening the line to one tusk, passing it through a slit at the back of the neck, looping it around a knob cut in the ice, and once more passing it through the slit in the neck. The loops acted as a pulley. Often a group gathered about the beast, helping to cut it up. The tusks and heart went to the successful hunter: the rest was shared.

IN the spring, a boat full of hunters would paddle silently to an ice floe to attack a herd of sleeping walrus. A lone hunter would jump quietly onto the ice and try to kill several walrus before the others, alarmed, tumbled into the sea. Swimming walrus were harpooned from the boat, an inflated sealskin being attached to the line to impede the animal's escape and keep it afloat after it died.

Cut off from the surrounding world by ice-filled seas, these daring hunters lived their own lives largely untouched by outside influences. In recent years they have been drawn into the world economy, and their lives have changed radically. But at heart they remain hunters, and the only labor in which they delight is the chase. They not only depend upon game for all of life's necessities, but they have the hunter's outlook on the world.

Today both the rifle and the power motor are used. Now the boat approaches the sleeping herds with the outboard turning over as slowly as possible. As soon as the range is good, several hunters begin firing. Angered walrus, especially young ones, may at-

Dr. Carpenter has lived among the St. Lawrence people and accompanied them on hunts. He is chairman of the Department of Anthropology at the San Fernando Valley State College.

tack. Swimming under water, they approach the boat on their backs and with their tusks try, sometimes successfully, to rip open the bottom of the boat. Others try to hook their tusks over the side of a boat and capsize it. Eskimos paint hulls red in the belief walrus fear this color. The men also stamp their heels in the boat, making a peculiar sound that they say walrus mistake for the sound of the dreaded killer whale. I can testify to the efficacy of this ruse: attacking walrus turn back instantly, like swimmers turning at the end of a pool. About 1936, a large herd was driven ashore on St. Lawrence Island by a school of killer whales. They were so badly frightened that while making their way up the beach in the surf, a pile up occurred and over two hundred were smothered or crushed. The Eskimos had an unexpected feast.

Because of its size and strength, the walrus has few other enemies. Hungry polar bears are said to attack it on land; I suspect this is rare. An Eskimo told me he had seen a bear creep up behind a walrus, lift a chunk of ice with both paws, and stun his victim with it. Any lifelong observer is bound to witness some strange incidents, but wild animals only rarely employ tools, and this tale is probably myth.

Walrus are also taken during winter. A team of hunters pulls the boat across the flat ice pans and fields of broken ice where huge cakes grind and pile against each other, constantly on the lookout for the dark specks that mean sleeping walrus. The problem here is to approach close enough so the animal can be harpooned after it is shot and before it can dive into water. A walrus may be fatally wounded, but if it can get under the ice before being harpooned, it is lost to the hunter. Traditional hunting was superior in this respect; it was also quiet and did not frighten nearby walrus. My impression of Eskimo marksmanship is that it is exceptionally poor and probably reflects the fact that hunters must get close enough to the walrus to be able to harpoon it almost immediately after shooting it.

Between 1900 and 1940, domesticated reindeer, introduced from Si-

Silhouetted against the Bering Sea, a hunting party rides in an open boat,

above, in search of walrus. After the hunt, boat returning to the Savoonga community on St. Lawrence Island is met by rest of villagers, *below,* who run to the shore to greet it. Island is in Bering Strait and has no harbor.

Skinning of a juvenile walrus is first step in the making of thongs for whips and harpoons. A small hide such as this one can be cut in a single long strip.

Savoonga woman cuts sinew thread to be used when stitching the walrus hides.

beria and herded for the first few years by Laplanders, replaced the walrus in the needs and minds of the Savoonga hunters. But, for reasons not fully known, these herds declined catastrophically after 1943. The blow was doubly hard to the villagers, for the walrus herds also declined, possibly as a result of the introduction of rifles and motors, although other factors may have been involved. In June, 1944, Ifkuluk, a Savoonga hunter, found fifty-four dead walrus on one of the Punuk Islands, about five miles off St. Lawrence Island. They were mostly females and were believed to have been killed during breeding activities. Seven years later, over fifty carcasses washed ashore along a ten-mile strip near Northeast Cape. An American zoologist examined them some months later. No definite cause could be established, but from several circumstances, it was assumed they died owing to a violent explosion in the Russian area along the coast of northeastern Siberia.

Dr. Charles Hughes, a Cornell anthropologist who lived in the neighboring village of Gambell during 1954-55, reported that "for food, the people for the first time became significantly dependent on outside sources of supply and not on their own efforts." But the hunts continue, for although walrus are no longer sufficient, they are nonetheless most necessary.

When weather prohibits winter boat-hunting, the men go by dog sled along the open leads. In certain areas this is especially dangerous, for if a current changes, a hunter may be swept away on an ice floe and marooned, sometimes to return, sometimes not. This is one of the real horrors of the Arctic. In many camps there is the silent memory of hunters lost and the visible evidence of amputees who survived, but lost their frozen limbs.

To approach walrus on level ice is extremely dangerous. They can move with astonishing speed when angered, even out of water, and in the sea, of course, they are formidable foes. But if one can get on rocks above them, it is quite safe to approach even large herds closely. I once stood just above a herd of about 1,200. One old bull in particular dominated a portion of the herd. He lumbered about his harem, trying to provoke some of the young bulls. Occasionally one would stand up to him: the two would weave clumsily about, glaring and snorting, until the contender backed down. The herd slept tightly packed, their tusks often get-

WALRUS HIDE is stretched on a frame and split lengthwise by one of few Savoonga women who possesses the skill. Two hides so divided will cover a skin boat. The plank on which woman stands is lowered manually as slow work progresses.

Boat owner in background supervises as woman covers a boat frame with new hides. Using sinew thread and a heavy needle, she begins to work on the prow.

Seamstress pulls thread taut as she labors to make the joining watertight. Female walrus hides are preferred to male hides, as they are more pliable.

ting in one another's way. At intervals they all put their heads up and shifted about, as if they were under water, coming up for air. I was close enough to hit the old bull's head with a stone; he turned to a neighboring bull and flattened him with a blow of his tusks.

When Eskimos dress the walrus, they cut them into rectangular sections of hide and blubber, leaving some meat attached. An incision is made on opposite sides of each slab, providing a handle. The heavy strips are then carried to meat cellars for storage. If a hunter wants a new harpoon line or whip, he makes two parallel incisions around the carcass and removes a "sleeve" of hide, which he cuts into a single, coil-like line and stretches between two rocks to dry.

Walrus are at home in water, but cannot swim indefinitely and must find ice or land. One herd found itself far from ice. In desperation they hauled themselves out onto the nearest shore, which, to their misfortune, was occupied by an Eskimo village.

For skin boats, or *angyaks*, two hides are split in half for their full length. mounted, scraped, and stretched. This is women's work, as is the sewing of the hides on wooden frames. The remarkable boats can remain in water for lengthy periods before the hide goes soggy and lashings loosen. In camp they are kept on racks, above drifting snow and hungry dogs.

The skulls are left lying about camp, but the tusks are not forgotten. Most tools are made of ivory, as are art objects. and after pups have gnawed off what scraps of meat remain, the tusks are carefully removed.

Eskimos believe these animals lead their own lives and have their own wills and desires. "Beast of the Sea, come and offer yourself in dear early morning," begins an ancient Eskimo prayer. A walrus must give himself freely to the hunter. without coercion. just as humans must interact freely.

When the hunter tells about it afterward, he often assumes a humble role: "It happened that a walrus appeared and an old harpoon had to be stuck in it." Yet. during the actual chase, hunters seem almost possessed. I have seen them in a frenzy of savagery, shouting, leaping across cracks in the crashing, moving ice, harpooning and stabbing these huge, snorting beasts. Iglulik Eskimos in eastern Canada shout: "Come. are there men among

you? Those here challenge you!" And at the noise the herd begins to mill angrily about, apparently waiting for a chance to attack.

This sort of electrifying performance is in sharp contrast with the usually quiet behavior of these people —a behavior so basic that scholars have advanced various theories to explain what the silent igloo-sitter is thinking. Early ethnologists believed he was in a self-induced trance; Freudians said that he was suppressing his anxieties. Both assumed there was an inner dialogue. I do not believe the silent Eskimo with his impassive face is necessarily thinking anything. Inner dialogue, far from being universal, is largely the product of literacy. To Eskimos, all thought is "outside." "If thoughts were *in* a mind, how could they *do* anything?" asked Ohnainewk, an Iglulik hunter. Thought, to the Eskimos, is everything outside of man, especially natural forces. But thought cannot exist without man. It makes itself known to man. It speaks first and man gives it shape and expression.

ORPINGALIK, a Canadian Eskimo, explained to the famous Danish explorer Knud Rasmussen: "Songs are thoughts, sung out with the breath when people are moved by great forces and ordinary speech no longer suffices. Man is moved just like the ice floe sailing here and there out in the current. His thoughts are driven by a flowing force when he feels joy, when he feels fear, when he feels sorrow. Thoughts can wash over him like a flood, making his breath come in gasps, and his heart throb. Something, like an abatement in weather, will keep him thawed up. And then it will happen that we, who always think we are small, will feel still smaller. And we will fear to use words. But it will happen that the words we need will come of themselves. When the words we want to use shoot up of themselves—we get a new song."

I have seen silent, gentle, slow-moving Eskimos, suddenly caught up in the hunt, accomplish astonishing feats of skill and daring. Yet there was consistency here. They were the same. They simply allowed the world to act toward them with complete freedom. But they were not passive: they freed this experience from its formless state and gave it expression and beauty. When you feel a song welling up within you, you sing it; when Eskimos feel themselves possessed by the hunt, they commit themselves fully to it.

The Eskimo language contains no first person pronoun, which in English is so important that we make "I" upper case, an honor otherwise restricted to gods and kings. Eskimo does provide a suffix to indicate participation in an experience, but generally even this is avoided, and an impersonal third person is used: "One has driven his spear into a walrus." Yet, despite the absence of individualism in our sense, there is often achievement, and while there is no "I," there is great dignity.

FLANKED by two hunting boats on their wooden racks, hide is stretched on frame to dry, after which it will be stored for future utilization as boat cover. When well cared for, such skins will withstand at least four years of hard use.

Husky pups perform service by cleaning meat from walrus skull. The tusks are removed to make tools and art objects.

A mother and daughter carry freshly killed auks, *right.* Child's dress is traditional, while mother's is mail order.

In their games there are no spectators, and in their hunts no idlers. They shout at walrus as if they were human, becoming involved emotionally in these one-way conversations. To literate man, this sort of behavior is not only alien, but offensive. Literacy creates a sense of middle distance, a perspective: it separates observer from observed, actor from action, subject from verb. Eskimo hunters, however, delight in being caught up in the "grammar" of experience, especially hunting. They make this same commitment to the technology of intricate machinery, and their achievements in mastering alien engines and repairing broken ones are truly phenomenal.

I lived with walrus hunters on several occasions, once for the better part of a year. Although my work has since taken me to a number of continents and among various tribes, these Arctic experiences are the only ones that will not go out of mind and be forgotten. I remember thinking once, when the sky was clear and my belly full: "I will never go back to civilization; this is a man's life." In the Arctic, where you experience cold and hunger, you also know the warmth and power that pour through you the moment you gulp down chunks of meat. You know the joy of your body when you are out on the moving ice, leaping cracks, marveling that your feet come down right, shouting, driving a lance in with every muscle. In the end, you begin to know something of yourself.

I returned to civilization, of course. The Arctic was not my world. It was alien, and always would be. But for brief moments, caught up by nature and by the challenges and skills of the hunt, I had felt fully human.

I think this was the same feeling an Iglulik hunter once expressed, and which Rasmussen caught even in translation—a translation that used "I" for a form we do not have: "I could not sleep, for the sea lay so smooth at hand. So I rowed out, and a walrus came up close beside my kayak. It was too near to throw, and I thrust the harpoon into its side, and the hunting float bounded over the water. But it kept coming up again and set its flippers angrily like elbows on the surface of the water, trying to tear the hunting float to pieces. In vain it spent its utmost strength, for the skin of an unborn lemming was sewn inside as a guardian amulet, and when it drew back, blowing viciously, to gather strength again, I . . . stabbed it with my lance. And this I sing because the men who dwell south and north of us fill their breathing with self-praise."

Merian said *Thysania agrippina* Cram. is on "a rubber tree," but modern botanists do not agree.

A Surinam Portfolio

In the late seventeenth century, the Dutch colony of Surinam, on the northern coast of South America, was so well hidden behind a tangled mangrove coast that even the pillaging Caribbean pirates made no attempt to raid the territory. The capital city, Paramaribo, consisted of some "500 houses made of wood and two of brick," and although the dense jungle rendered most of the land uninhabitable, even for the Indian population, the colonists were busy establishing cocoa and sugar cane plantations. It was on these inhospitable shores that Maria Sybilla Merian disembarked in 1699 with her daughter Dorothea. The gently reared, fifty-two-year-old woman had one purpose in undertaking the two-month trip from Amsterdam—to collect and paint Surinam insects.

Maria was the daughter of Matthäus Merian, a Swiss who had married the granddaughter of Theodore de Bry, a noted Frankfurt am Main illustrator and engraver. Merian subsequently inherited the business. Maria de Bry died after presenting him with seven children; not long afterward he remarried, and Maria Sybilla was born to his second wife in 1647. When Maria was four years old, Matthäus died, and the same year her mother married Jacob Marrell, a well-known painter of the "Utrecht school," which

Typically, larva, pupa, and adult of a moth, *Arsenura armida* Cram., are shown on one plant.

Watermelon supports pupa and "square caterpillar" of the Limacodidae family.

Unidentifiable insects feed on this papaya tree, whose fruits taste like "the very best turnips."

was chiefly distinguished for its use of insects in flower paintings. Her stepfather early recognized Maria's talent. He taught her painting and took her with him on field trips, despite the objections of her mother, who felt such excursions were distinctly unladylike.

In 1665, when she was 18, Maria married Johann Graff, a fellow student; their first daughter, Johanna, was born in 1668, and the family later moved to Nuremburg. There Maria Sybilla seriously began to study and paint nature.

"From my youth I have been interested in insects," she stated, "first I started with the silkworms in my native Frankfurt am Main. After that . . . I started to collect all the caterpillars I could find to observe their changes . . . and painted them very carefully on parchment."

In 1678, she was hard at work on part one of her first ambitious scientific work, a description of European insects, when a second daugh-

Fruit, wrote the artist, is Surinam grapefruit. Caterpillar is of genus *Urania.*

ter, Dorothea, was born. The volume, titled *Der Raupen wunderbare Verwandelung und sonderbare Blumennahrung,* was published the following year and was enthusiastically received. This was attributable, in part, to the author's use of copper plates, for by the late seventeenth century engraving had definitely been established as a reproduction — not solely an artistic — medium and the method permitted a scientific precision far exceeding that of woodcuts. In 1681 Marrell died, and his stepdaughter returned to Frankfurt with her children to join her mother. This, Maria's first separation from her husband, eventually led to their estrangement. One reason for the break lay in Maria's growing interest in a religious sect known as the Labadists, which had a colony in a castle in Friesland. The group had been founded by a French mystic, Jean de Labadie, as an evangelistic cult. De Labadie died in 1674, but the Fries-

Artist's interest in plant growth is shown by various phases in development of cocoa fruit.

The photographs on these pages were made from a 1719 edition of Maria Merian's work *Metamorphosis Insectorum Surinamensium,* which is in THE AMERICAN MUSEUM's library. The editors of NATURAL HISTORY would like to express thanks to DR. H. E. COOMANS, Research Fellow, who translated Madame Merian's text from the Dutch, and to those Museum entomologists who assisted in the identification of the butterflies and moths.

land colony continued to prosper. The Labadists were a strict and fanatic group whose main creed stated "man is nothing." They did not believe in formal marriage or worldly goods, and established missions, including one in Surinam. Caspar Merian, a stepbrother of Maria, had entered the Friesland retreat some years before and had interested her in their way of life. In 1685, two years after her second volume on European insects was published, Maria Sybilla and her children, then aged 17 and 7, joined the group in the castle. All evidence indicates that she was not a strict Labadist; rather, she sought refuge from the world.

Her husband visited her in 1686 and entreated her to return to him, but Maria refused. She never again lived with Graff or used her married name; in fact, while in Friesland, she made a will calling herself a widow, although in truth her husband did not die until 1701.

Her stay at the Labadist colony allowed her to see the cabinet collections of many prominent Frieslanders, who were incidentally Labadists. She also learned the Dutch language before departing, in 1691, for Amsterdam and further study. Here, again, she was able to examine collections, and said, "in Holland, I was amazed how many beautiful animals came from the East and West Indies. . . . This stimulated me to undertake a long and pleasant journey and set sail for Surinam. . . . "

Soon after their arrival at Paramaribo, Madame Merian and Dorothea, who was also a collector and an artist, visited La Providentia, a plantation that was apparently a Labadist colony. Here, close to the jungle, they began collecting caterpillars, and the date and stage of each metamorphosis was recorded with care.

AFTER their visit to La Providentia, mother and daughter returned to Paramaribo and then journeyed down the Commewijne River into the interior, where they continued collecting despite Maria's sufferings from the effects of yellow fever. During this period she probably was increasingly dependent on the local population to collect for her. In her description of the picture on page 38, she said, "The creeping Worm on the stem is orange, she was brought to me by a black woman slave, who told me that Grasshoppers came from it, it changed into a brown bladder, and (according to the testimony of the inhabitants) a green animal, as in this plate, should come from it, which gradually gets wings like the flying Grasshopper [praying mantis] here has. I did not observe this experience, because the round Cocoon died. . . . " Yet she accurately depicted the tropical praying mantis, *Choeradodis strumaria* Linn. and its egg case.

She also studied and painted the flora of the country (not always, however, as precisely as could be wished). Her text contains criticisms of the Dutch and Indians alike for their failure to grow the native fruits. "Here I show the American Cherry . . . apparently this fruit could be cultivated better, if the country was inhabited by a more active and less profit-seeking population," she said, with some asperity, referring to

Hairy white caterpillar on leaf above cashew is probably *Hesoscia eriophora* Sepp.

Artist included rainbow boa, which has laid eggs on cassava root, "to ornament the page."

In *Systema naturae,* Linnaeus refers to this plate as *Morpho achilles*, but later descriptions disagree with Merian's picture of the insect.

Hunting spiders attack hummingbird on a calabash tree, while surrounded by army ants—and what may be parasol ants at winged stage.

Despite artist's omission of white dot on front edge of adults' wings, larva and butterflies on the pomegranate may be *Morpho menelaus* Linn.

Caterpillar, said artist, rolled up "neatly" in grape leaf on August 26, 1700, and was an adult (perhaps *Pholus labruscae* Linn.) in twenty days.

the plantation system that concentrated on "money crops" of cane and cocoa.

Insects, however, remained her primary interest. Of army ants and parasol ants (page 35) she said: "There are very large Ants in America, who strip trees bare as brooms in one night, they have two curved teeth, built like scissors, and with these they cut the leaves from the trees, and let them fall down, so the tree looks like a European tree during wintertime. . . . " She correctly described the process by which ants make "bridges" of themselves and "thousands of Ants walk over this Ant bridge." She was further astonished by the ants' voraciousness when, annually, they leave their underground nests and "in hordes go into the houses . . . from one room to the other devouring all the insects . . . everyone leaves and when the whole house is cleaned out, [the ants] go to the neighboring house, and finally back to their nest again."

The hunting spider, which appears with the web-spinning spiders (page 35), is feeding on a hummingbird, and although one of Madame Merian's critics declared that the activities occurring on this plate "are to a considerable extent fabulous," they have, on the contrary, been proved to have considerable accuracy, despite the fact that the hummingbird's nest contains four eggs instead of the usual two.

Butterfly, of genus *Papilio*, is feeding on citrus plant. Merian said the caterpillars have yellow horns that emerge if animal is touched.

MADAME MERIAN did most of her work in 1700 following her yellow fever attack, which forced her to return to Europe the following year. She arrived in Amsterdam on September 23, 1701, and probably went to live with Johanna, who had married and remained behind. Dorothea, in turn, married soon after their return and was widowed a few years later. Maria arranged her notes and sketches and compiled her cabinets of specimens, and when her acquaintances viewed them, they persuaded her to publish her findings. She consented, because, in her words, "this will be the first and most curious work ever painted in America." She finally arranged financing for the project, despite complaining that "costs to complete publishing this work discouraged me. . . . " Although trained as an engraver, she did not undertake this task, which is credited to Pieter Sluyter and Joseph Mulder, with one plate made by D. Stoopendael.

Metamorphosis Insectorum Surinamensium, was published in a folio volume in 1705. It was printed in Amsterdam in both Latin and Dutch, and contained sixty plates engraved from Merian's paintings. Her preface gives a tantalizing glimpse of the scientific community at the beginning of the eighteenth century; it also contains what may be an oblique reference to the public reception that greeted Antony van Leeuwenhoek's description of the life he viewed through his microscope — many contemporaries stated that he saw more in his imagination than in his instrument. "I could enlarge on the text [of the plates] but the world nowadays is very delicate and the feelings of the scientists are different so I choose to be simple in my descriptions . . . so everybody can make his own interpretation, and apply the text to his own feelings."

In 1719, two years after the author died, an Amsterdam publisher, J. Oosterwyk, issued a second edition of the formidable work and included twelve more plates. He carefully stated that the additional plates were obtained from the paintings of Maria Merian, but added that the "engravings had not been completed by Merian." Certainly it would be difficult to attribute the book's last two plates to her, textually, artistically, or scientifically. For instance, the text accompanying one states that European frogs metamorphose from fish into frogs, while American species change from frogs into fish! The last plate shows what appears to be an East Indies, rather than a South American, landscape and concerns the same mysterious fish-to-frog-

On pepper plant with fruit and flower are three stages of a *Phlegethontius rustica* Fabr.

Tropical praying mantis is in flight, left. Nymph is center right; egg case is below on stem.

to-fish cycle. Although her treatment of plants and animals was considerably less accurate than her studies of insects, it is doubtful that Madame Merian would have gone quite so far afield. In most of the sixty drawings by the artist, the foliage of the plants showed caterpillar depredations – a feature lacking in the last plates. This is another reason why the latter group is of questionable attribution.

Madame Merian received acclaim for her work, but little money; she made a new will about the time the book was published, stating that she was penniless, and was supported by her children. Meanwhile, the third and final volume of her European insect work had been prepared and published, and at the same time a second edition of the first two volumes was issued. In all of these she dropped her married name, although it had appeared in the earlier editions. By 1717 all three parts were available in Dutch and Latin, and later editions were in French.

Madame Merian never relinquished her beloved Surinam project. In 1714, Johanna and her husband left for the colony, where Johanna was to do more collecting for her mother. Soon after their departure Maria Sybilla suffered a stroke, further weakening her already precarious health, and that year Dorothea's second husband, an engraver named George Gsell, published a portrait of the grandam – a stern, ill, and saddened visage. She never lived to see the new specimens; she died January 13, 1717, before Johanna's return.

Perhaps no eulogy could ever be so important to this remarkable woman as the knowledge that her work had earned the interest and respect of the scientific community. Primarily, that community approved her eagerness to observe from nature. Linnaeus referred to her plates in his works, and even the great Goethe was aware of her contributions to the knowledge of the era. Although much of what Maria herself presented as "science" has since been questioned, this in no way detracts from her stature. Madame Merian was not a trained scientist; she was a trained observer, which enables modern taxonomists to identify many of her plants and insects.

As James Duncan observed in a memoir of Maria Sybilla Merian, in volume 30 of *The Naturalist's Library*, published in 1835; "The . . . text, it is true, is not of much value; but it must be borne in mind . . . that this branch of natural history [entomology], as well as every other, was still in its infancy. . . . It is not, there-

Young tegu, a blue tropical lizard, was placed on cassava plant simply for decorative effect. Butterflies are species *Anartia jatrophae* Linn.

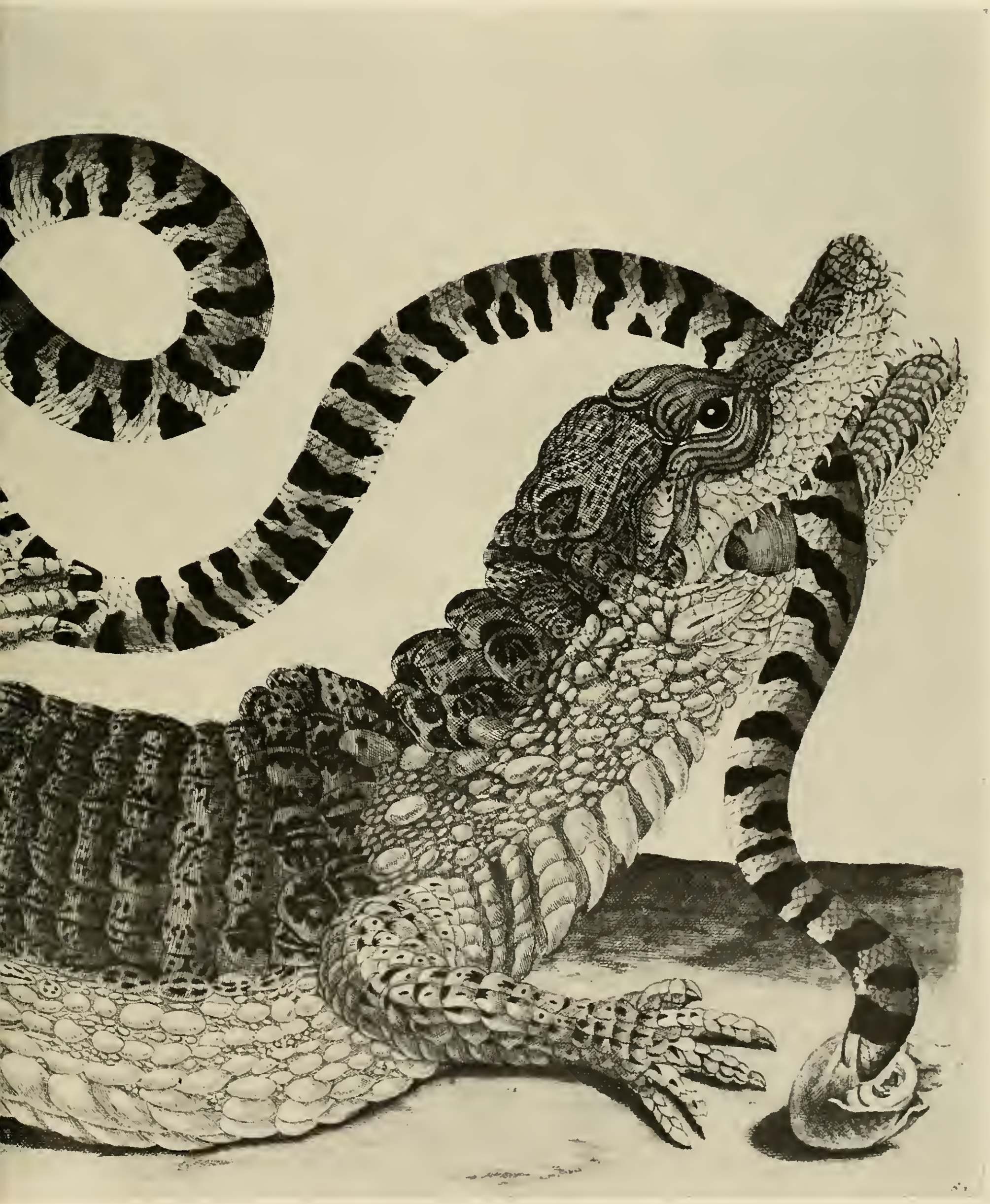
fore, surprising that Madame Merian should occasionally have fallen into error. . . . "

In his recent work, *The Art of Botanical Illustration,* Wilfred Blunt states that although Merian was primarily an entomologist, she "was certainly one of the finest botanical artists of the period immediately following upon the death of Nicolas Robert in 1680 . . . her art derived almost entirely from the great flower painters of 17th century Holland."

Her labor was not financially rewarding for her family – they were apparently forced to sell her precious plates to the publisher of the posthumous editions. When Maria Merian was

Spectacled cayman, engaged in remarkable conflict with New World pipe snake, may not be Merian's work, although included in posthumous editions.

buried in Amsterdam, her death certificate was signed by the Registrar of the Poor. She did, however, have her own grave; the spot is now occupied by a trades school. Curiously, despite her stature with her contemporaries, Madame Merian still rests in obscurity. Virtually all information about her is only in the Dutch language; even her magnificent plates are seldom reproduced. From this distance it is, of course, difficult to evaluate her influence, but in her dedication to precision, even within her own limited frame of reference, she was an integral part of the scientific pragmatism that basically characterized the Age of Enlightenment.



Osprey, or fish hawk, is sole member of the Pandionidae family, which is world-wide in its range. Unique feature of this diurnal bird of prey is the reversible outer toe on foot, which, like bird's bill, is modified for catching fish.

Resilient Predators

Osprey's survival is based on adaptability

By E. Thomas Gilliard

The fish hawk, or osprey *(Pandion haliaetus)*, is a brown-and-white, eagle-sized hawk that occurs widely in the temperate and tropical regions of the world. It belongs to the order Falconiformes, a group comprising seven families of birds of prey—two extinct and five surviving. Some of the Falconiformes are as small as sparrows and prey on insects, while others, like the golden eagle, are large enough to kill fully grown wildcats. One family, the Sagittariidae, consists of the aberrant, long-legged secretary bird of Africa; another, the Pandionidae, is confined to the osprey.

Unique among diurnal birds of prey in its feeding habits, the osprey lives almost entirely on fish, which it takes by diving into the sea. A bird of highly variable nesting habits, it has been known to build on the ground, on rocky crags, and in tall dead trees, all on a single island. The nests may be mere scrapes in the sand or massive structures rivaling those of the greatest eagle; the eggs may be nearly pure white, spotted, or almost entirely chocolate brown. Furthermore, during the same time period some nests will contain eggs, while in others young are ready to fledge.

Perhaps the secret of the osprey's success in its fight for survival (particularly against man) is this variability, which probably fosters rapid modification through natural selection, enabling the bird to keep pace with rapidly changing ecological conditions. As a case in point, in certain areas ospreys were customarily shot down because of their propensity for building large stick-nests on power transmission poles. Despite this persecution the birds hung on, and today along coastal roads in New Jersey and many other areas it is common for utility companies to provide special poles topped with nesting platforms. The ospreys readily take to such man-made nesting locations, perhaps because today they live chiefly near the sea, where nesting locations are often few and far between. In fact, the birds may begin building nests within hours after enlightened bird watchers have erected pole-platforms at strategic points.

Both the male and female osprey build the nest. Later, two to three eggs—rarely four—are laid. These are incubated for thirty-five to thirty-eight days, usually by the female, who also does most of the brooding and feeding, at least for the first half of the seven-week period the young remain in the nest. During these early weeks, the male brings fish to the female, who cuts it up and gives it to the young. Later both parents feed the offspring, and between them may visit the nest with food only two or three times daily.

In hunting, the osprey flies 50 to 150 feet over the water. Upon seeing a fish, it hovers and then plunges, with its widespread talons stretched far forward in front of its bill. Wings canted backward, it enters the water to seize its prey. Occasionally the fish is too large and carries the hawk under water to its death. But usually, aided by its needle-sharp talons and the rasplike scales sheathing its toes, the hawk clasps the back of the fish and emerges from the water, then lofts its sharply pointed wings and takes flight. At that

Variety of nesting sites used by the fish hawk include the tops of trees and power transmission poles. After years of use, nest may attain six foot width.

Dark eye streak of northern osprey is not so apparent in Caribbean birds.

moment a fortunate bird watcher is most apt to view one of the epic spectacles of nature—a bald eagle attacking a fish hawk to steal its prey. The eagle vigorously dives at the fish hawk, which attempts evasive flight with its heavy prize. But almost invariably the osprey drops its prey in fright, whereupon the eagle furls its wings, dives, and is usually able to overtake and seize the falling fish in mid-air.

In the New World, ospreys breed in North America and winter from the Gulf States south—including Florida, where there is a resident population. Others fly as far south as the Galápagos Islands, Chile, and Argentina. According to some local banding records, the young birds are highly nomadic, spending one or more years in South America before returning north. This tendency may have something to do with the resiliency of the species to the encroachments of man, and probably is the reason for its having a world-wide range rivaled only by the peregrine falcon and the barn owl among the 8,600 known bird species.

In addition, the osprey often recolonizes territories from which it has

Male bird returns to nest with fish, on which it subsists almost entirely.

Rasplike scales on undersides of the bird's toes help it to grasp the prey.

PARENT BIRD stands guard over newly hatched offspring and an unbroken egg.

long been extirpated. For example, in 1959 the fish hawk returned to the British Isles, where for a century it has not existed as a breeding species. That same year a pair of the birds returned to nest beside a fresh-water lake in Scotland. This so greatly pleased local ornithologists that a special guard was posted at the nest to watch over the birds. Nevertheless, a collector, with his face blackened like a commando, scaled the tree one night and stole the eggs. These he broke when he fell during his descent, although he managed to escape. Newspapers publicized the theft and even offered rewards for apprehension of the culprit. Immediately, thousands of spectators came to see the nest tree, and special viewing stands were built to accommodate them. Funds were subscribed for the protection of the birds, which, by great good luck, relaid. Since 1959 they have produced three families of young: all of which indicate something of the charm of this resilient bird of prey.

DR. GILLIARD, Associate Curator of Birds at THE AMERICAN MUSEUM, is a regular contributor to these pages.

Egg Retention: Pattern in Evolution

Reproductive complexity assists in the survival of a species

By Donn Eric Rosen

In the world of living things, it is customary to speak of population explosions. Most of us know this phrase as it applies to man, but it may equally call to mind hordes of lemmings, infestations of insects, or the uncontrolled spread of water hyacinths. If the average non-scientist is aware of the great creativity of life, it is usually because of his contacts with the seemingly inexhaustible supply of pestiferous or of food organisms—the countless billions of microorganisms or the estimated trillion herring of the North Atlantic.

Yet, nature has a savage side, in which are inherent great powers of destruction. In the early history of evolutionary thinking, a struggle for existence was hypothesized, in which those living things that are least capable of adapting to prevailing conditions are destroyed, whereas the strongest individuals survive and reproduce the qualities that allow their survival. This struggle was thought to induce a natural selection of the fittest (or the best-adapted) organisms, thus causing the formation of new varieties—and, very gradually, new species—better able to survive.

Today, however, we know that the mechanism of natural selection, which helps to explain the *fact* of evolution, is not alone a simple matter of tooth and claw or the evasion of inhospitable physical conditions. Efficiency in reproduction methods is equally important, so it is not surprising to find that even the simplest organisms may be reproductively complex. This article deals with one of the many reproductive specializations to be found in modern bony fishes, and one, furthermore, about which the evolutionary history and advantages may be surmised.

Male guppy, below, moves its sexually modified anal fin forward and prepares to deposit sperm bundles within female.

The fishes in question—the Poeciliidae, a family of viviparous killifishes—provide a particularly good example of reproductive specialization. First, their sexual modifications are exceptionally numerous, and can be seen with the naked eye. Second, a great deal is known about their biology and the structure of their sexual parts. Third, many of the species of poeciliid fishes are familiar to the public because they are hardy and can easily be kept in a home aquarium; perhaps the best-known is the guppy.

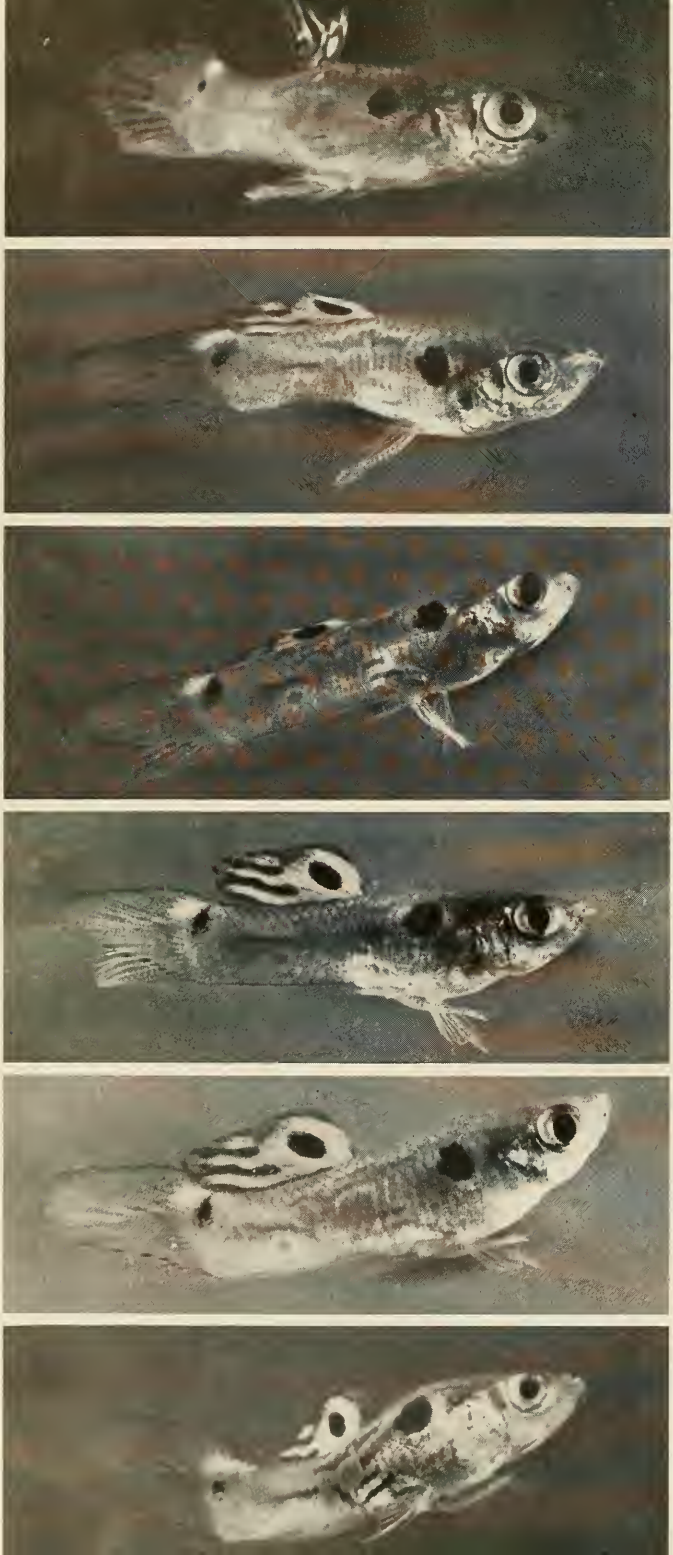
Almost as well known is the mosquitofish, whose larviphagous (and reproductive) capabilities are so remarkable that the species has been used in mosquito abatement programs in more than 70 countries. A single 2 1/3-inch female mosquitofish has consumed 225 mosquito wrigglers in a single hour. The effectiveness of the species in mosquito control depends largely on its reproductive capacity: at the end of August, 1961, 12 female and 20 male mosquitofish were placed in an experimental pond on Long Island, and less than three months later the population was estimated at nearly 500 individuals.

The family Poeciliidae is made up of about 130 species, distributed continuously from southern New Jersey and Illinois, throughout tropical Middle America and the West Indies, where they reach their greatest abundance, and south to Buenos Aires. Some species inhabit fresh-water environments; some are found in waters adjoining mud volcanoes, in which the temperature rises as high as 95° F.; others winter under a layer of ice. Numerous poeciliids spend their lives in brackish water, and a few others make their homes among the roots of the salt-water mangroves of oceanic islands. Because of their adaptability and their small size (the male of one species is only 3/5 of an inch long), they are abundant in regions from which most fresh-water and many marine fishes are virtually excluded.

A coastal environment seems to present no great hardship to the majority of poeciliids, which seems to have originated in the coastal habitats of lower Central America, perhaps during a time when parts of Panama and Costa Rica were entirely under water. Thus, by virtue of ancestry alone they are today well suited to life in the Middle-American bridge that lies between North and South America.

Their demonstrable success in this region is underscored by the poor representation of the other fresh-water groups, which includes a closely related family of killifishes—the Cyprinodontidae. Like the poeciliids, these fishes are extremely hardy, and many of the species have adapted themselves to some rather startling extremes of environment. Although they are a diversified and abundant group in continental waters, only a handful of species has filtered over into Middle America and the West Indies. By contrast, about 90 per cent of the fishes inhabiting the fresh waters of the West Indies are members of the family Poeciliidae—which brings us to the point of our story. The Cyprinodontidae are entirely egg-laying fishes: the Poeciliidae give birth to living young, which can swim and feed when they are born.

It is difficult and, on occasion, im-



possible. for aquatic animals to reach certain geographical areas. Obstacles such as unsuitable temperatures, currents, or salinity intervene, or perhaps each region is interrupted by varying, closely spaced habitats that cannot support the number of adults required for breeding aggregations.

In general, egg-laying species can colonize a new region if adult males and females arrive and remain together and survive until mating time. For a viviparous species, problems of range extension and effective colonization are much less complex. A single pregnant viviparous female carrying fifty young can transport a potential breeding population to extraperipheral areas. In addition, females of some of the viviparous species can store sperms that are introduced by the male at one mating, and deliver as many as eight successive broods after this single insemination. It is still a question, however, whether an oviparous species and a viviparous species with equal resistance to natural hazards and equal powers of dispersal can colonize new frontiers with equal vigor, or whether one shows some advantage over the other in the process.

SOME biologists believe that viviparity has advantages for a species other than those concerned with penetration into new areas. For example, it has been suggested that viviparity protects them against biological hazards inherent in all environments. Eggs that are deposited and fertilized externally may be eaten or become diseased; they may be killed by desiccation or by being swept into an unfavorable situation. A female carrying young within her may obviate many of these dangers, although she herself is subject to perils that may quite suddenly destroy her and her entire brood.

Such dangers confront the females of egg-laying species as well. Here the loss of the adult with her cargo of unfertilized eggs seems to be relatively much greater, because oviparous species often compensate for the potential dangers to every set of eggs by producing them in larger quantities.

One may almost think of the relatively higher egg production of oviparous species as a built-in margin for error that nature has carefully

SEQUENCE shows movements of male guppy, *Lebistes reticulatus*, while it swings gonopodium forward and to side.

A POECILIID FISH from northern South America, *Tomeurus gracilis*, exhibits an unusually specialized gonopodium. It includes antenna-like structures that emerge from the tip and aid male in locating correct spot for sperm deposition.

calculated to allow a "reasonable" percentage of survivors. From this viewpoint, oviparous animals must manufacture a relatively large amount of living material to achieve the same reasonable percentage of survival attained by the young of viviparous species. Moreover, the young of oviparous fishes frequently hatch from the egg as larvae—helpless and grotesque little animals that must lie about for a time until their embryonic food supply is absorbed and they are finally able to swim and feed actively. The young of viviparous forms, on the other hand, are frequently born at a very advanced stage of development, and from the very first behave and appear like miniatures of the adults.

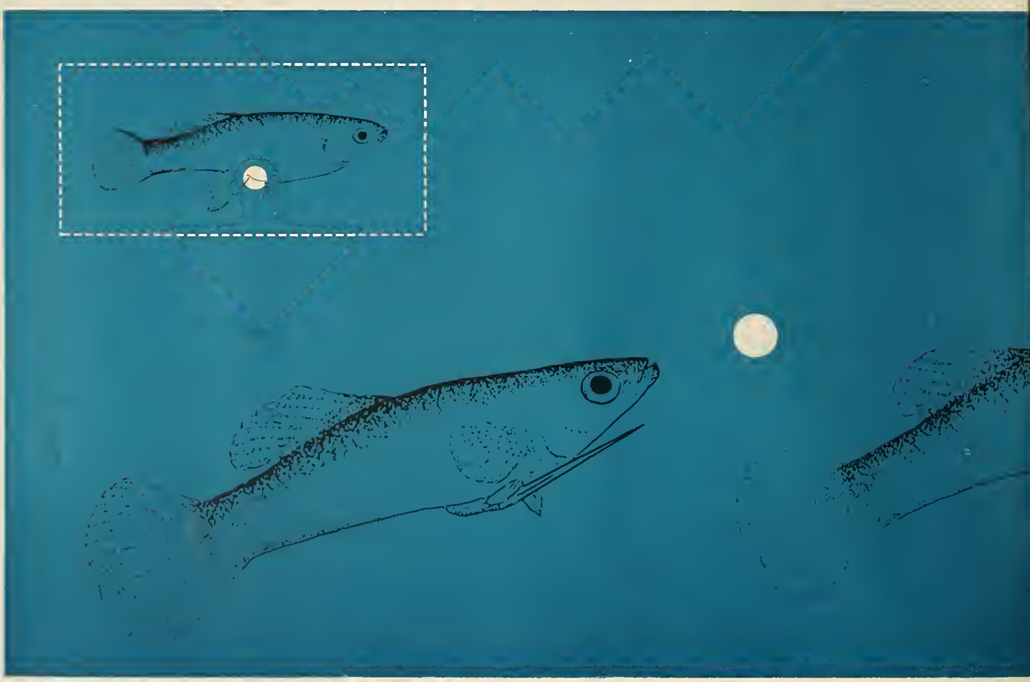
Now, consider an egg-laying species of fish that simply casts its sexual products freely into the water. Place such a fish at mating time in a tidal embayment, or in a swiftly flowing stream or river. Clearly, unless the sperms could somehow be channeled, many of them would be swept away, and countless eggs would go unfertilized.

Suppose the fish then developed some means of localizing the flow of sperms toward the eggs—by directing them with the anal fin, for example. Numerous sperms would undoubtedly be washed away in this case, too, but many more would be turned *toward* the egg, and fewer eggs would be left as a sterile reminder of nature's imperfections. Last, suppose that the fish then developed a means of localizing the process of fertilizing the eggs within the confines of the female's body—for example, by introducing the sperms into the female's sexual pore. Certainly, in the present context, internal fertilization represents the ultimate economy of sperms, and would have great advantages for fishes that live and breed in flowing waters. Once internal fertilization is accomplished, we may say that that species is preadapted to evolve means of retaining the eggs that have been fertilized.

A slight delay in the extrusion of the eggs to allow internal fertilization could in time be translated into a longer period of retention while the female sought an environment suitable for oviposition. When the fertilized eggs are retained until they hatch with-

MOVEMENTS of gonopodium and pelvic fin form cup to receive sperms, which are directed by folded gonopodium.

Rodlike anal fin of male *Pseudoxiphophorus bimaculatus* readily identifies it. In contrast, the female's anal fin is considerably shorter and noticeably fan-shaped. Species is from tropical lowlands of Mexico and Central America.



in the female, and when the intrinsic food supply of the egg—the yolk—is largely replaced by nutritive materials from the maternal circulation, viviparity may be said to have evolved.

Although viviparity seems to be a real economy for a fish, regardless of its environment, it is nonetheless a comparatively rare phenomenon. Of the more than 300 families of bony fishes (not including sharks), fewer than ten are known to include species that give birth to living young. These figures appear to contradict everything that has been said about the presumed advantages of viviparity. One salient reason why relatively few fishes are live-bearing is suggested by the extraordinary complexity of the structural modifications that make internal fertilization possible in an aquatic environment. Sometimes an entire fin has become altered, solely for the purpose of introducing sperms into the female. One may readily appreciate that the loss of an important organ of locomotion could be a very real disadvantage to a fish that lives in a world inhabited by predators.

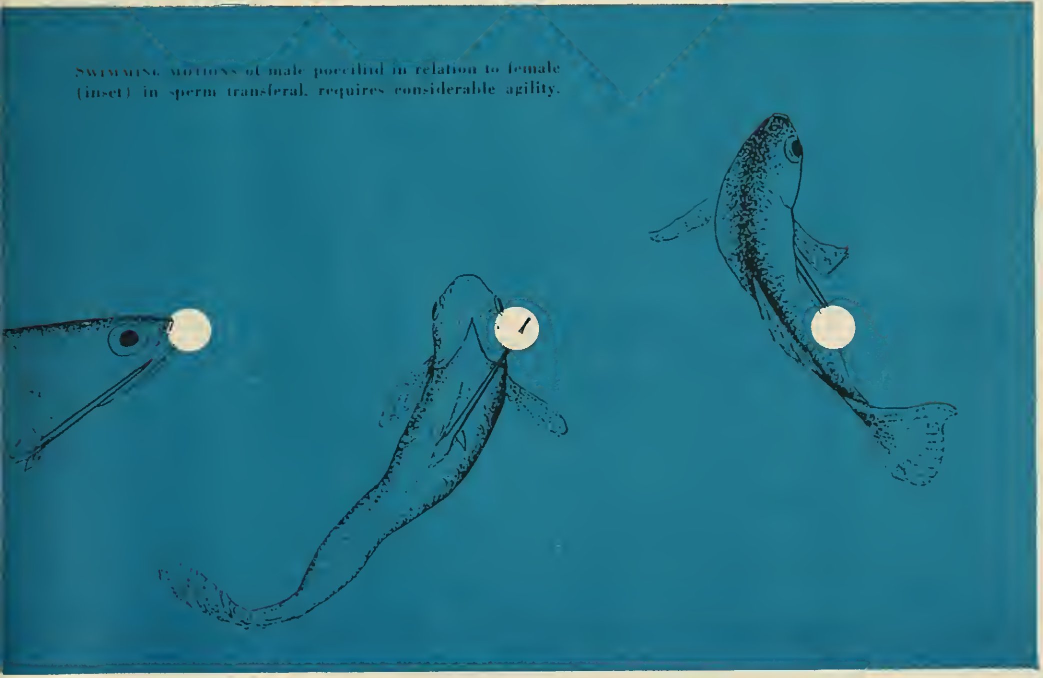
To understand the complexities, it might be well to emphasize some simple aspects of general fish anatomy. The skeleton, for example, is essentially a large, bony skull joined to one end of a long rod that has widely spaced spines above and below. The rod, between the two sets of spines, is the animal's backbone, made up of a large number of small, hourglass-shaped vertebrae. These are flexibly hinged together to enable the backbone to bend from side to side. At seven points along this central body skeleton are other bony structures—some platelike and some shaped like small combs—and these are the internal fin supports. There are also a pair of pectoral fins, a pair of pelvic fins, a dorsal fin, an anal fin, and a caudal fin. Between the pectoral fins and the front of the anal fin, the lower spines of the central skeletal axis are not developed, and rigid support in this abdominal region is supplied by a series of paired ribs.

The poeciliid fishes form a striking exception to the basic pattern. As the male and female poeciliid approach maturity (usually in one or two months), the lower spines located above the anal fin begin to erode. This process first appears near the base of the forward-most spine, where it attaches to the backbone. As more and more of the spine erodes, the same process begins in the second spine, and so on, until three to five spines are affected.

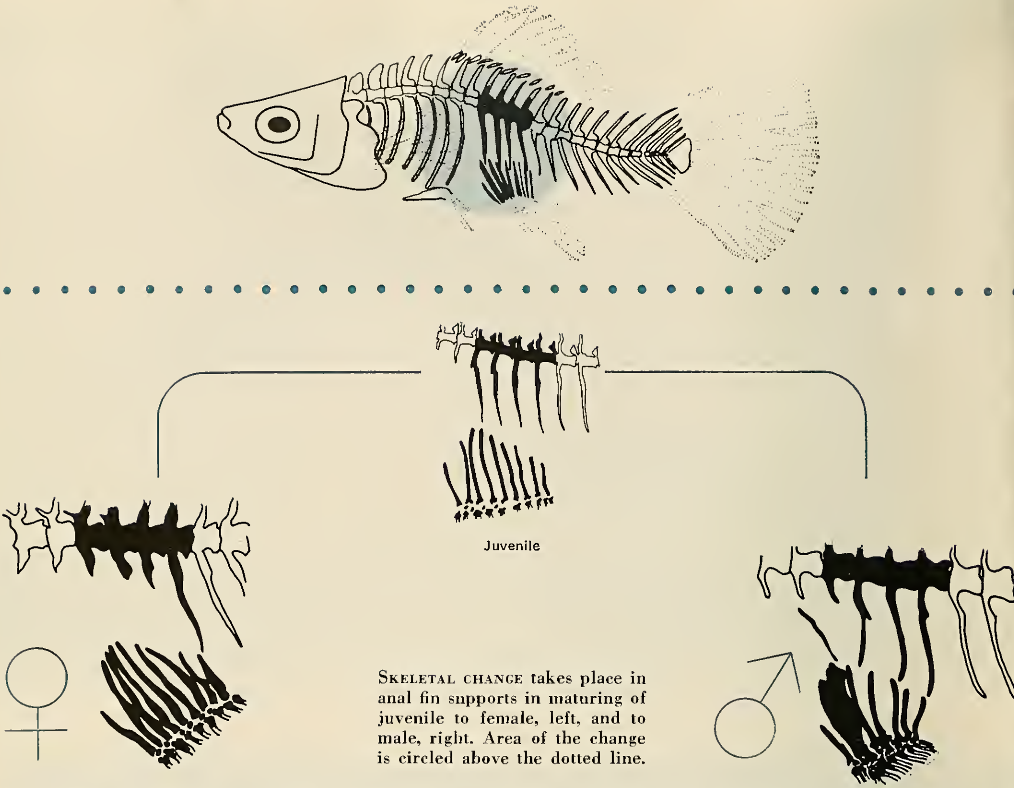
Dr. Rosen is Assistant Curator in The American Museum's Department of Ichthyology. His special interests are in systematics and comparative and functional morphological studies.

In the female, the process of organic erosion continues unabated until the forward two or three spines have vanished completely, thus making way for the large ovary soon to be distended with young. In the male, the same process of erosion occurs, but just when the first spine has become detached from its base or mostly eliminated, a building up process, which effectively counteracts the tissue breakdown, is instituted at the spine's weakest point. At the same time, the underlying anal fin and its internal supports migrate forward in the body, drawing with them the lower spines, which bend at their weakened bases to accommodate the shift of the anal fin. This phenomenon ceases at about the time the building up process produces a lump at the spine's point of flexure.

As the male's internal skeleton is being modified in response to increasing quantities of male sex hormone, the bony rays of the anal fin are



Swimming motions of male poeciliid in relation to female (inset) in sperm transferal, requires considerable agility.



SKELETAL CHANGE takes place in anal fin supports in maturing of juvenile to female, left, and to male, right. Area of the change is circled above the dotted line.

also being altered substantially. At first, the only sign of change is a slight increase in the length of the first few rays. As sexual development proceeds, the third, fourth, and fifth anal fin rays show a sudden spurt of growth, and in the space of a week or two, they have doubled or trebled in length. At the very tip of these tremendously elongated rays, a series of tiny barbs, hooks, teeth, and other structures develop, and when they have been fully formed, the male fish is sexually mature and undergoes no further anatomical changes. The long and complicated anal fin of the male poeciliid is called a gonopodium, and is used to transfer sperms to the female.

The functional importance of the male anatomical modifications may be appreciated within the framework of poeciliid courtship and mating behavior. In many species, courtship begins when a male, having attracted the attention of a female, spreads his fins, quivers his body, swings his gonopodium forward, and gently touches the female with mouth or fins. The female responds either by remaining comparatively still or by assuming a tail up position near the male. The male then swings behind and slightly below the female, moves the gonopodium fully forward and to one side, and places its tip near or within the sexual pore of the female. If, during this mating contact, sperms are actually passed, the male signals the occurrence by suddenly breaking away and dashing rapidly about in the immediate vicinity of the female.

THE entire procedure sounds relatively simple until one realizes the contortions the male must perform in order to transfer the sperms successfully. The complex maneuvers involve the following adjustments of position: (1) an increase in the angle of pitch as measured by the higher position of the head in relation to the tail, which enables the male to give an upward thrust with the gonopodium; (2) a roll in the horizontal plane that brings the gonopodium closer in for greater accuracy; (3) a pivoting of the body around a point located behind the head, which tends to bring the entire body and the raised gonopodium next to the female sexual pore.

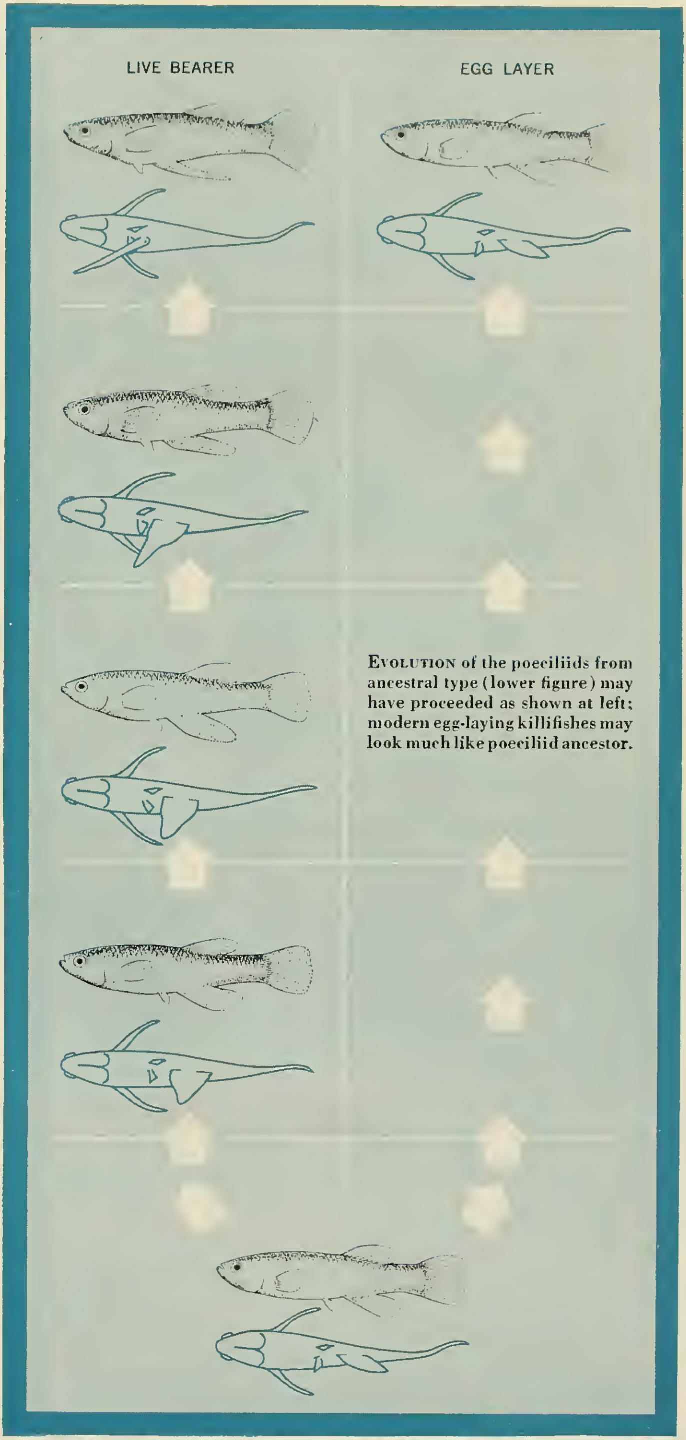
In most fishes, the anal fin (which in poeciliids is the gonopodium) is so far back on the body as to be completely out of the fish's visual range. If the fin has developed farther forward in the body, the raised fin tip is brought within the visual field, and allows sight cues to increase the effectiveness of the mating contact.

Moreover, a fish usually pivots its body back and forth as it moves forward in the water, and the pivoting point is located just behind the head, more or less coinciding with what is termed its "center of mass." Since the fish pivots on this point, it follows that the body area around the center of mass has the least amount of side-to-side movement. It also follows that the fins located nearest the center of mass will experience less side-to-side sway than will fins located nearer the tail. Hence, as the modified anal fin, or gonopodium, of the male poeciliid shifts closer to the center of mass, the male is able to adjust the fin's position during courtship without having to com-

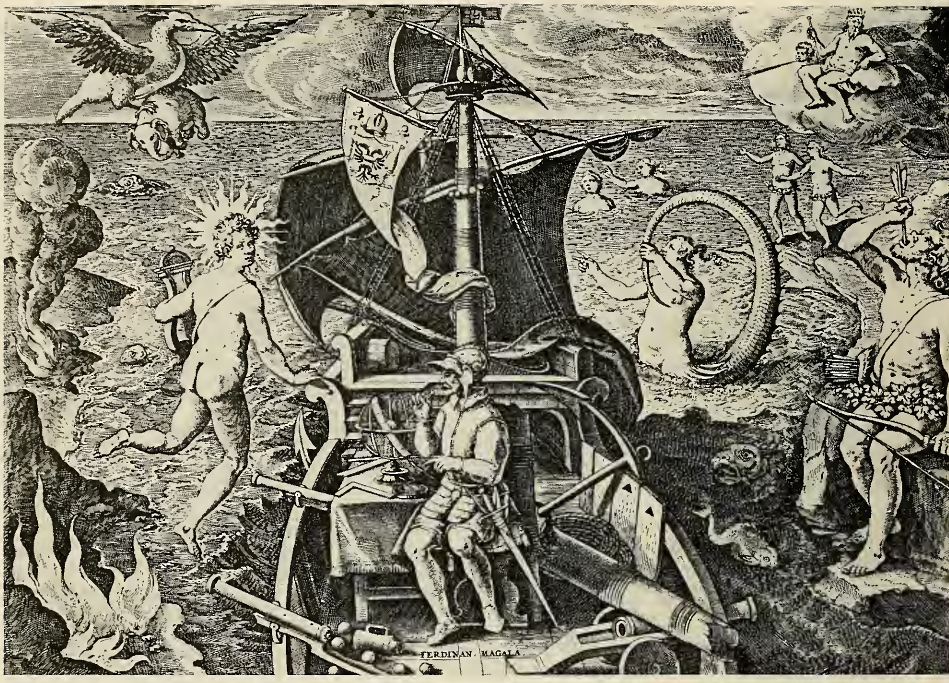
pensate for extensive body motions.

Superficially, both courtship and mating in the oviparous cyprinodontid killifishes are quite similar to the activities in the poeciliids. The male cyprinodontid utilizes the same courtship display, except that it cannot swing its unmodified anal fin forward. But the male cyprinodontid elevates and spreads all its fins to their fullest extent during courtship, and in mating behaves in a manner suggestive of poeciliids. The male circles to a position below and behind the female, pitches, rolls, and pivots until the sexual pores are apposed, and then bends and stretches the anal fin forward as far as it will go. In this position, the fin is slightly cupped in the middle and is directly underneath the female's sexual pore. The female quivers slightly and ejects her eggs. At the same instant, sperms are forced from the sexual pore of the male and are deflected toward the falling eggs by the inclined anal fin. Thus we may see that even in the egg-laying killifishes, the anal fin directs the sperms toward the egg. It is not hard to imagine how such a fin might evolve into one that could be raised just a little more, cupped just a little more, and lengthened just a bit, until it had become transformed through time and thousands of generations into a very simple type of gonopodium. Indeed, everything about the egg-laying killifishes seems to point to poeciliid specializations, and biologists therefore feel justified in thinking that millenniums ago the ancestors of poeciliid fishes looked much as their egg-laying relatives do today.

We may never know precisely how much of an advantage viviparity confers. It is only an informed guess that live-bearing plays a dominant role in allowing the poeciliids to penetrate with comparative ease into regions that are less hospitable to their oviparous cousins. Poeciliids are, after all, heirs to but a small part of the world's aquatic domain—mainly fresh and brackish waters of tropical Middle America and the West Indies. Perhaps their success in this twilight zone between the great, stable fresh-water basins of the continents to the north and south is simply a measure of the extent to which organisms, in perpetual evolutionary contest, may develop the most intricate specializations to become a notch more efficient and better adapted than their closest relatives.



Evolution of the poeciliids from ancestral type (lower figure) may have proceeded as shown at left; modern egg-laying killifishes may look much like poeciliid ancestor.



MAGELLAN ON VOYAGE is depicted in a woodcut of 1523.

SKY REPORTER

Explorer's odyssey kindled interest in the Magellanic Clouds

By SIMONE DARO GOSSNER

THE MAGELLANIC CLOUDS are among the most remarkable features of the sky. Unfortunately for northern observers, they are visible only in the Southern Hemisphere and to 15° North Latitude. They remained virtually unknown to the Western world except for scattered accounts by navigators of the late Middle Ages and early Renaissance, who reported sighting them in the vicinity of the Cape of Good Hope. Because of this, they were originally called the "Cape Clouds," but received only scant attention.

On September 20, 1519, the great Portuguese navigator Ferdinand Magellan sailed with five ships from the Guadalquivir estuary on the westward voyage that would make him famous. The purpose of the venture—to find a westward route to the Moluccas—forced him into southern Atlantic waters and eventually around the Horn. The Cape Clouds were sighted again. Magellan died in the Philippines and never saw the fulfillment of his dream, but one of his ships succeeded in returning home, completing the first trip around the world. This proof that the earth is spherical was the principal reason for the acclaim that greeted the expedition. Eyewitness accounts of the trip fired the imagination, and every detail, including astronomical observations, was eagerly studied. The Cape Clouds finally received the attention they had been denied in the past. Henceforth they would be called the Clouds of Magellan.

These two bright patches of nebulosity, one larger than the other, resemble the Milky Way in brightness and appearance, but they are found at some distance from it. The Large Cloud (LMC) is situated in the constellation Dorado and spans about seven degrees, or nearly fourteen times the diameter of the moon. The Small Cloud (SMC) is in Tucana, close to the globular cluster 47 Tucanae (NATURAL HISTORY, June-July, 1962), and is about four degrees wide. Both are easily seen with the naked eye.

The Clouds are small galaxies. They are, in fact, the nearest neighbors of the Milky Way and are usually considered its satellites, just as NGC 204 and NGC 221 are called the satellites of the Great Galaxy M31 in Andromeda (NATURAL HISTORY, November, 1962). But there the similarity ends. Whereas NGC 204 and 221 are well-ordered elliptical systems, the Magellanic Clouds are irregular conglomerations of stars, gas, and dust. Only in the LMC is there a slight hint of spiral structure. Bright blue stars are found in abundance, together with Cepheid variables, red supergiants, novae, gaseous nebulae, and globular clusters.

The distance of the Magellanic Clouds from earth is not

known with great accuracy and has undergone a number of revisions in the past fifty years. It would be presumptuous to assume that the value adopted at present is the definitive one. At any rate, it is currently estimated at roughly 200,000 light-years, or about 1.2 billion billion miles.

It is indeed unfortunate that the determination of the Clouds' distance proves to be so troublesome. They are near enough to earth for their individual stars—at least the brighter ones—and other constituents to be studied in detail. Information gathered in this way can be applied to more remote galaxies, but only by extrapolation. Actually, the entire distance scale of the universe depends on the knowledge of our distance from nearby galaxies such as the Clouds and Andromeda. Since the most powerful telescope, the 200-inch Palomar instrument, penetrates about 30,000 times farther into space than the Clouds' distance, an error in the latter would be magnified 30,000 times at the confines of the observable universe.

The greatest difficulty in astronomical studies is that most galaxies lie tantalizingly beyond the effective reach of instruments. If a star of a particular type exists in the neighborhood of the sun, it can be photographed, its magnitude can be measured, its spectrum can be recorded and studied, its light variation, if any, can be plotted, and so forth. Knowledge thus acquired may then be used to draw conclusions about stars of the same type found at distances too great to allow complete study. The stumbling block in this procedure, unfortunately, lies in the assumption that stars of a given type always behave in the same way, whether they are in close proximity to the sun or in a distant galaxy.

Such methods and their far-reaching consequences, both good and bad, are illustrated by the manner in which Cepheid variable stars have been used to measure the distance of the Magellanic Clouds. Cepheid variables have a remarkable property—the period of their variation is related to their intrinsic brightness. This property first came to light in 1912, in a study of Cepheids in the SMC. Observations revealed that all Cepheids with the same apparent brightness had the same period, and the brighter the star the longer the period. Since all these Cepheids were at the same distance from us (that of the SMC itself) it was evident that the relation held true for their intrinsic brightness (or absolute magnitude) as well. Just as street lights appear fainter the farther away they are, the apparent magnitude of a star also decreases with greater distance. Therefore the distance of a star may be estimated if both its absolute and its apparent magnitudes are known. For the SMC Cepheids, however, only the apparent magnitude could be measured, and astronomers had to look elsewhere to find the corresponding intrinsic brightness. Fortunately, or so it seemed at the time, Cepheid variables had been found in some globular clusters with known distances. The period-versus-brightness relation of Cepheids could thus be calibrated, yielding the distance of the two Clouds and, eventually, the scale of the universe. Alas, it was found a decade ago that cluster Cepheids are systematically 1.5 magnitude fainter than those in the SMC, corresponding to a factor of 2 in the estimated distance. Surprised astronomers found their universe was twice as large as they had estimated.

Clouds of Magellan comprise Small Cloud, upper left, and Large Cloud, right. Bright star, lower left, is Alpha Eridani.

THE SKY IN DECEMBER

From the Almanac:

First Quarter	December 4,	11:48 A.M., EST
Full Moon	December 11,	4:28 A.M., EST
Last Quarter	December 18,	5:43 P.M., EST
New Moon	December 26,	5:59 P.M., EST

On December 22, at 3:15 A.M., EST, the sun will reach winter solstice—southernmost point in its apparent yearly path—and winter will begin in the Northern Hemisphere.

For the visual observer:

Mercury, in the evening sky. will remain close to the sun throughout the month. By December 31, it will set 90 minutes after the sun and may be found very low in the southwest at dusk; its magnitude on that date will be —0.5.

Venus. in the morning sky, will reach greatest brilliance (—4.4 magnitude) on December 18. It will shine brightly in the southeast before dawn and will rise two hours before the sun on December 1, three hours before on December 15, and three and one-half hours before on December 31.

Mars. in Leo, will increase steadily in brightness (from +0.3 magnitude on December 1 to —0.4 on December 31) as it swings back toward the point nearest earth in its two-year orbit. It will rise in the east at 10:00 P.M., local standard time, December 1, 9:00 P.M. December 15, and 8:00 P.M. December 31. It will pass overhead about seven hours after rising and will be high in the west at dawn.

Jupiter, in Aquarius (—1.8 magnitude), will be in the south at dusk. setting in the west at 11:15 P.M. December 1, 10:30 P.M. December 15, and 9:30 P.M. December 31.

Saturn, in Capricornus (+0.9 magnitude), will be visible in early evening, setting at 9:00 P.M. on December 1, 8:00 P.M. on December 15, and 7:00 P.M. on December 31.

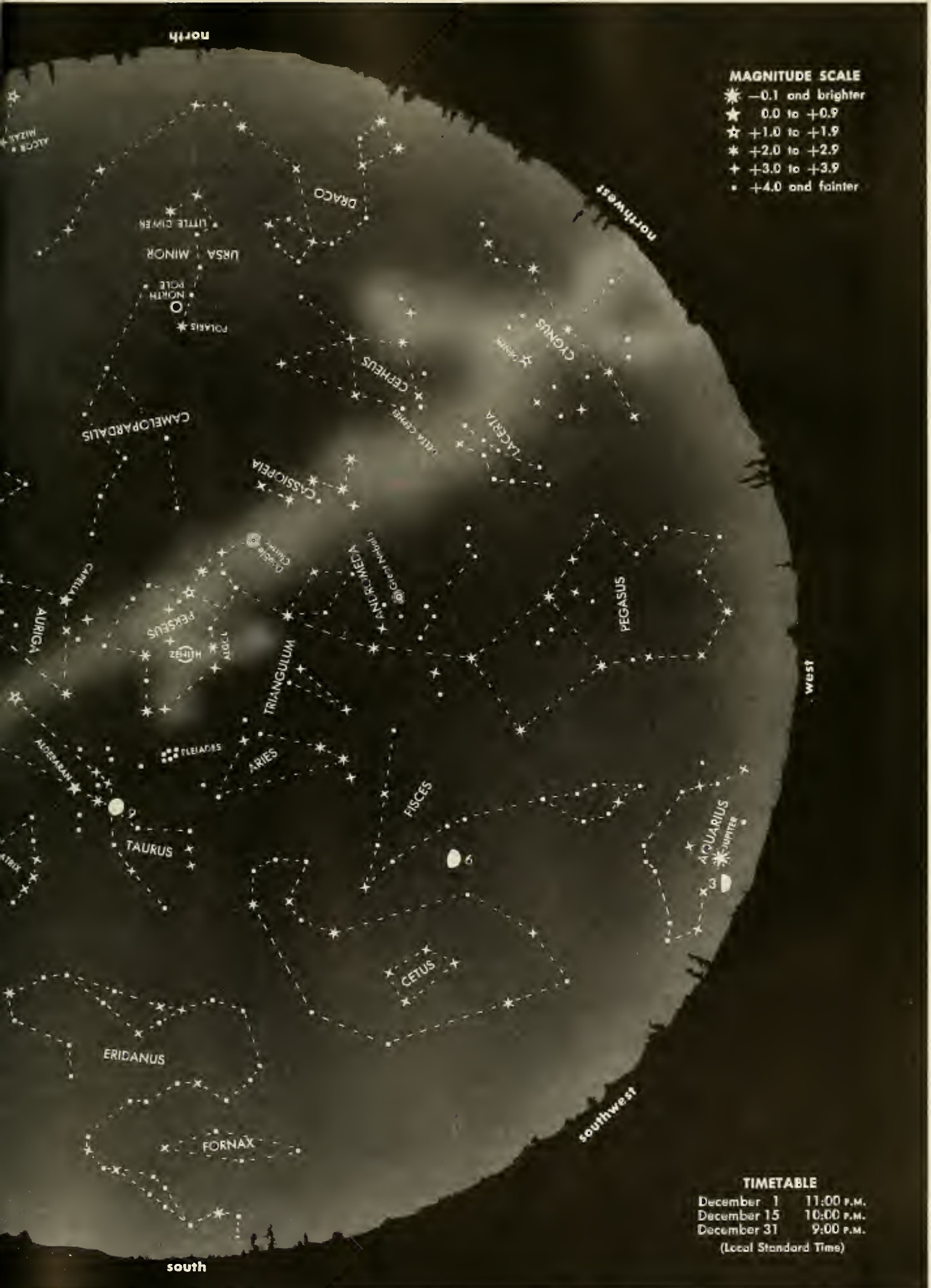
The Geminid meteor shower is expected on December 13. Although this shower averages 50 meteors per hour at maximum (as viewed by a single observer), the brightness of the moon—two days past full on that date—will seriously hamper attempts at observation. The Ursid shower, on December 22, with an expected maximum rate of 15 meteors per hour, will be relatively easier to observe.

Marking the Seasons

Were it not for certain climatological factors, it would seem more logical to take the solstices and equinoxes as the mid-point of each season rather than its beginning. As a matter of fact. a fragment of a calendar found in a Roman villa dating approximately from the start of the Christian Era gives the beginning and end of spring as February 9 and May 14. The latter date, being also the beginning of summer, coincided with the heliacal rising of the Pleiades at that period—that is, the first day of the year on which the Pleiades were seen rising before the sun. Therefore, the custom of taking the equinoxes and solstices as dividing dates between the seasons has not always existed. The same calendar fragment gives March 22 as the spring equinox, about midway between February 9 and May 14. Mystifyingly, however, it gives for "mid-spring" the date of April 28, which it identifies as the heliacal setting of Aries. By mid-spring was probably meant "the height of spring," and one may assume that the Romans had noted how the seasons lag behind their corresponding equinox or solstice.

On the preceding pages, MRS. GOSSNER presents the final article in her 1962 series—a survey of the celestial sphere.

To use this map outdoors, hold it in such a way that the direction you wish to face is printed at the bottom. The constellations depicted below the point marked "zenith" are visible in that part of the sky at the time indicated.



north
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
northwest
west
southwest
south
MIZAR
ALCOR
DRACO
URSA MINOR
LITTLE DIPPER
NORTH POLE
POLARIS
CEPHEUS
CYGNUS
DENEB
CAMELOPARDALIS
LACERTA
DELTA CEPHEI
CASSIOPEIA
Double Cluster
ANDROMEDA
Great Nebula
PEGASUS
CAPELLA
AURIGA
PERSEUS
ALGOL
ZENITH
TRIANGULUM
PLEIADES
ALDEBARAN
ARIES
PISCES
TAURUS
9
6
3
AQUARIUS
JUPITER
CETUS
ERIDANUS
FORNAX
TIMETABLE
December 1 11:00 P.M.
December 15 10:00 P.M.
December 31 9:00 P.M.
(Local Standard Time)

Emerging from its shell, *Helix pomatia* thrusts out edges of foot, following it with the head. Eyes push up from dorsal feelers, *center,* and animal gropes for ground, overbalancing shell on which the epiphragm can be seen.

POTLID MOLLUSK

Calcareous seal protects land snail

When cooling temperatures signal the coming of fall weather, the land snail prepares to hibernate. It seeks out a winter resting place beneath fallen leaves, or burrows under the surface of the soil, and there secretes a calcareous substance that forms a casing, or epiphragm, across the shell opening. Thus protected from cold, it becomes torpid and awaits spring. In April or May it pushes off the epiphragm, and emerges from the shell. In summer the snail may seal itself against excessive heat.

The subject of these photographs is *Helix pomatia,* a large land snail whose range is south, east, and middle Europe, Denmark and south Sweden. Its delicate flavor has made it a popular food since Roman times. Despite its simple external appearance *Helix pomatia* is surprisingly complex anatomically. Many of its internal organs are in the visceral hump, an area that always remains inside the shell. A strong columella muscle that winds through the spirals attaches the mollusk to its shell and enables the head and foot to be contracted inward.

At its head the snail bears two pairs of tentacles. The eyes, near the tips of the dorsal pair, perceive general shapes and, like the skin, are sensitive to sudden changes in light. The frontal tentacles are organs of touch and chemical sense. *Helix pomatia* chews vegetation with the aid of an astounding number of teeth—usually some 27,000 arranged in about 175 rows. The number is variable, as old worn teeth are continually being replaced by new ones. One individual snail was known to possess 40,725 teeth.

The species is sometimes called the apple snail, although it does not derive its name from the Latin *pomum,* apple, but from the Greek *poma,* potlid, a term descriptive of its calcareous seal.

Fully extended tentacles help the mollusk to locate surrounding vegetation. Visible on the shell are characteristic horizontal bands and vertical growth ridges.

WASHINGTON NEWSLETTER

By Paul Mason Tilden

As cities go, the nation's capital is a handsome one, with beautiful federal buildings, tree-lined streets, and parks and green spaces scattered in profusion over its 69 square miles. Its business section boasts no concrete canyons, for its office and commercial buildings are limited by regulation to a modest vertical rise. All of this is as it should be, for Washington is the Federal City; despite some serious geographical limitations, it is a showcase for its proprietors, the people of the United States.

This pleasant state of affairs is not one that is viewed comfortably by residents as either automatic or perpetual. There is a strong and constant downtown push for "better business"; better business obviously calls for more and bigger roads into town, and for years the conservation organizations headquartered in Washington, in alliance with civic organizations and prominent citizens, have struggled to prevent the capital city from concrete embalmment; from being overrun by the superhighways, expressways, freeways, ramps, and bridges that are proposed for it every year.

This stand is taken on the grounds that: (a) Washington traffic is congested enough as it is, and hardly needs the additional flood of vehicles that expressways would invite; and (b) the city's primary reason for existence is not commercial or industrial, and it should remain aesthetically pleasing and unharrowed by a mélange of new roads and ramps. It is noted also that such "improvements" are quite often advocated for land now occupied by the city's parks and green spaces. In a recent instance, a Washington conservation organization played a prominent part in court proceedings that blocked—temporarily, at least—conversion of one of Washington's finest woodsy parks into a high-speed expressway.

While most expressway projects for the city are proposed in the name of "planning for the future," conservationists and some others have long suspected that underlying motives are not glacially pure. They were thus recently amused and gratified when a city highway official, being heard by a House appropriations subcommittee in defense of a huge, new road-and-bridge network for the District, expressed alarm that "anyone would seriously propose something that might disrupt the economy of the nation by raising doubts in the mind of people with reference to automobile transportation." Noted, too, was the fact that the hearings were well sprinkled with bridge and highway engineers, representatives of trucking associations, gasoline and tire dealers, and some others whose altruistic interest in the matter might be open to question.

To date, the warning specters of a future Detroit in cobwebby ruins and the nation's economic muscles in paralysis have not persuaded Washington conservationists that the "concrete jacket" is preferable to the park and the green space, better business or no.

Ducks and Farmers

Duck hunters who fancied they had fewer feathered targets on which to exercise their skills during the 1962 season were correct; there were fewer ducks to be taken especially of canvasback, redhead, and black species. Shooting of canvasbacks and redheads was entirely prohibited during the current season, as it was in the previous year. The nation's duck population is at an all-time low.

Duck-shooting regulations are promulgated by the Department of the Interior on the recommendation of the Waterfowl Advisory Committee, composed of various state delegates and conservation organization officials; the regional knowl-

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Mr. Tilden regularly contributes his observations of the Washington scene to Natural History. He is editor of National Parks Magazine.

edge of committee members is pooled with information and recommendations from the U.S. Fish and Wildlife Service to produce a sound base for Department of Interior action and regulation. Official cause of the duck scarcity: a continued severe drought in the duck-breeding grounds of the northern United States and Canada, especially in the important prairie pothole country.

Conservationists unofficially add another cause, too; one that is seldom prominent in government releases. This is the continuing drainage—in some instances with benefit of government subsidy—of glacial potholes in the northern plains country, and of marshlands elsewhere; a drainage designed to add more productive farmlands to those already overwhelming the nation's warehouses with surpluses. Vanishing with the potholes are myriad, vital waterfowl breeding grounds.

Pointing up the anomalous aspects of Washington policy toward both ducks and farmers is the current warfare between the Bureau of Reclamation and the Fish and Wildlife Service, both in the Department of the Interior, over the future of the great Tule Lake–Klamath marshlands of northern California and southern Oregon, which are used by some 80 per cent of the Pacific flyway's migrating ducks and geese. The 100,000-acre area, which for years has been both a national refuge for waterfowl and a rich agricultural land, is squarely in the sights of farmers and homesteaders, who argue—with the blessing of the Bureau of Reclamation—that they should put more of the refuge under the plow. Fish and Wildlife has stoutly resisted the proposed incursions.

Introduced into the 87th Congress by Senator Kuchel of California was a bill that would forbid the opening of any more Tule Lake–Klamath refuge lands to farmers and homesteaders. The bill has passed the Senate, but at this writing is still in the appropriate committee.

Living Space for Wildlife

Apropos of the preceding paragraphs, it might be noted that the Department of the Interior's Migratory Bird Conservation Commission has, over the course of the past few months, authorized the establishment of a number of new national wildlife refuges. These were: the Harris Neck Refuge, south of Savannah, Georgia, of 2,686 acres; the Alamosa Refuge, in the San Luis Valley

of southern Colorado, of 9,429 acres; the Davis Island Refuge, near Vicksburg, Mississippi, of 25,942 acres; the Eastern Neck Refuge, 2,071 acres on the Eastern Shore of Maryland; the Primehook Refuge, in Sussex County, Delaware, of 11,233 acres; the Toppenish Refuge, in Washington State's Yakima River watershed, of 12,379 acres; and the Lake Nettie Refuge, in McLean County, North Dakota, of 2,890 acres. The Commission also authorized land additions to several previously existing refuges in parcels ranging from as little as a half-acre to more than 7,000 acres.

The Migratory Bird Conservation Commission is by law composed of the Secretaries of Interior, Agriculture, and Commerce, two senators, and two representatives, with a number of state fish and game commissioners (or their equivalents, such as commission directors, etc.) as members ex officio.

The national wildlife refuges, with a total acreage of about 290 units now covering roughly 28.5 millions of acres, are not, and were not particularly designed to be, complete wildlife sanctuaries where the guns of hunters are never heard, although certain of them *may* be. To this extent the term "wildlife refuge" is something of a misnomer. Interior's Fish and Wildlife Service, which has immediate jurisdiction over the areas, may prescribe hunting seasons and regulations within them, or may proscribe hunting completely, depending on the local and general population condition of the animals using a particular refuge. In this sense, wildlife refuges are game management units rather than sanctuaries in the stricter sense of the word. Indeed, many refuge acquisitions are financed by funds received from the sale of federal duck stamps to hunters, and to a smaller extent to other wildlife enthusiasts and philatelists. Most conservationists—even those of the strict preservation segment—feel that the many collateral benefits to wildlife of all kinds fully justify the existence of the national wildlife refuge system.

Success at Point Reyes

Among the numerous areas that have been legislatively proposed for national park or seashore status, perhaps none has stood in need of more immediate congressional attention than the twin seashores of Point Reyes in California and Padre Island on the south coast of Texas. Both of these tracts have been under immediate threat of development; indeed, certain sections of Point Reyes were under the cleats of the bulldozers even as Congress deliberated its merits as a national preservation.

During these closing days of the 87th Congress' second session, a bill sponsored by California Senators Engle and Kuchel and already safely through the

Senate during the first session, passed the House of Representatives with a mere scattering of dissent, and with only a few minor amendments. Authorized was a Point Reyes National Seashore of approximately 53,000 acres on the scenic shores of Marin County, California, roughly 35 miles north of San Francisco.

Of the 53,000 acres to be acquired eventually and set aside for national recreational use, about 26,000 will constitute a rather remarkable "pastoral zone," where the present pattern of land use—almost exclusively ranching and dairying—will be carried on as in the past, a part of the scene to be preserved. Congress stipulated that pastoral lands are safe from government acquisition by condemnation as long as landholders behave themselves and keep their lands from adverse uses.

Conservationists have not strongly opposed such hybrid preservations in the past—somewhat similar compositions were made in Everglades National Park a number of years ago, and more recently in the authorization of Cape Cod National Seashore—but they point out an inherent weakness in park legislation that authorizes inholdings of any sort. If inholders kick over the traces, the National Park Service, as the agency immediately concerned, possesses the letter of the law but no acquisition funds.

As in the case of the newly authorized Cape Cod National Seashore in Massachusetts, enabling legislation for Point Reyes provided no funds for an immediate start at land-buying. Shortly after the final passage of the bill, however, its sponsors in both House and Senate dispatched an urgent letter to President Kennedy requesting a $5 million special appropriation for the National Park Service to acquire land in threatened portions of the Point.

A little less than two months after the Point Reyes authorization, the House easily passed Texas Senator Ralph Yarborough's bill to bring about 80 of bow-shaped Padre Island's 117 miles into the national park system as a national seashore. Long, narrow Padre Island is a barrier beach that stretches from Corpus Christi on the north to Brazos Santiago Pass, in the general vicinity of the Mexican border, on the south. Separated from the Texas mainland by the Laguna Madre, it is a solitary and still-unspoiled haven for adventuresome or troubled humans. Yarborough's Padre Island bill had been passed by the Senate earlier in the year

by a comfortable margin; the final legislation was, however, somewhat in the nature of a compromise between the 8[?] miles asked in the Senate bill and the 65-mile preservation called for in two House-sponsored bills. The House generously added another million dollars to the four millions requested by Yarborough for land acquisition, and the bill went to the President for his signature considered a certainty.

Changing of the Chiefs

SHORTLY after the previous installment of this report was placed in type, a figure long familiar to the nation's conservationists announced his voluntary retirement from public life. This was Dr. Richard E. McArdle, career forester, who for the past ten years had been Chief of the U.S. Forest Service in the Department of Agriculture and the guiding hand behind the policies that governed some 185 millions of acres of national timber and grasslands.

At 63, Dr. McArdle could look back over thirty-nine years of public service, most of it in forestry. During that time he accumulated uncounted awards and honors, both national and international, in forestry and conservation. Dr. McArdle, a native of Lexington, Kentucky, graduated from the University of Michigan, an institution that has furnished the nation with many an able conservationist. He was succeeded as chief forester by one of his assistant chiefs, Edward P. Cliff, who also has made a career in forestry.

Rays of Sunshine

CONSERVATIONISTS are often regarded by a part of the public as professional peddlers of bad news—a breed that views the world through glasses especially dark-tinted for the trade. The conservationist counters by saying that his reputation stems from the nature of his profession—that his vulnerability to the charge is an occupational hazard.

Conservationists have been able to take a more hopeful attitude toward the futures of three species of animals—two birds and a mammal—that until recently seemed quite likely to join the roll of the extinct. First of these is the whooping crane, for which the United States Fish and Wildlife Service, as well as conservationists, scientists, and lay citizens, has done a masterful job of both publicity and protection. A late winter count of the big birds at the

Aransas National Wildlife Refuge on the Texas coast showed that thirty-three adult and five young whoopers had accomplished the long flight south to Aransas from the 17,300-square-mile wilderness of Canada's Wood Buffalo Park in northern Alberta and the Northwest Territories during the fall of 1961. (Wood Buffalo was actually established to preserve the northern species of the American bison, but it also serves importantly as a nesting and breeding ground for the whooping crane.)

In 1938, first year of official count, the whooping crane was within fourteen birds of extinction. Now there are forty-five. Thirty-eight are in the wild, six are in the New Orleans Zoo, and another is in San Antonio, Texas. It is a hopeful figure, but not yet a wholly safe one.

The second bird for which the future had until recently looked dim is the rather un-gooselike Hawaiian goose called the *néné*, presently confined in its breeding grounds to a strip of barren black lava on the great shield of Mauna Loa in Hawaii Volcanoes National Park.

From an estimated population of 25,000 in the latter part of the eighteenth century, the *néné, Branta sandvicensis*, declined rapidly with the influx of the white man. Excessive hunting, plus destruction of *néné* habitat by the white man's camp followers—the dog, the rat, and other exotics—had reduced the big bird's numbers to an estimated fifty by the first decades of the twentieth century. Rather late in the day, the Territory (now state) of Hawaii decided that something should be done.

First, *néné*-hunting was outlawed. Then, in 1958, a Hawaiian goose restoration program got under way with a financial boost from the U.S. Fish and Wildlife Service. A breeding program began under the supervision of a professional ecologist, and in 1960 twenty young *néné* were released to join their wild companions on Mauna Loa. These were followed by another twenty in 1961. It is now thought that under close

protection the *néné*, a graceful goose that has seemingly renounced watery ways for life in the barren *aa* fields of Mauna Loa, may well attain a population figure that will insure the survival of the species.

The third animal for which the future seems much brighter is the tule elk, or dwarf wapiti, a mammal that once roamed the interior valleys of California in great numbers. It was brought to the brink of extinction during and after Gold Rush days by excessive hunting.

First described scientifically in 1905 by Dr. C. Hart Merriam, of the old Bureau of Biological Survey (now the Fish and Wildlife Service), *Cervus nannodes* derived its common name from the tule swamps of Kern County, the natural refuge in which were found the few remaining representatives. It is said, probably fancifully, that by 1870 there remained but a single pair of elk in the tules; a less romantic but probably more accurate figure might be eight or ten.

Under the personal protection of a conservation-minded Kern County rancher, the remnant herd began to increase; but since the tule elk subsists to a large extent upon grasses, and competes in this respect with domestic herds, its problems also increased. Various attempts were made to transplant the mammals to less competitive terrain; these either failed or were abandoned.

In 1932, the California State Park Commission set up a small tule elk refuge at Tupman, near Bakersfield, but this was quickly overgrazed, and the mammals live in the refuge today under a baled-hay economy, almost as in a zoo. However, some other elk from Kern were transplanted to the Owens Valley of Inyo County, just east of the High Sierra; these have become the important remnant of the species, and their numbers reached 313 by December of 1961.

Here again, despite occasional herd reductions, the elk compete for sustenance and space with man's domestic creatures, producing controversy and conflicts of interest. The obvious answer to the mammal's problem of survival is a refuge of sufficient size and suitable habitat to insure the perpetuation of the race in as natural a setting as possible.

Toward this end the Committee for the Preservation of the Tule Elk was formed in 1960. Its prime purpose: to establish some 240 square miles of the southern part of Owens Valley as a permanent sanctuary for the animals. The nature of the committee's staff and advisory board, which includes some distinguished names in the fields of science and conservation, seems to indicate that any gestures made by the group will not be idle ones, and that the diminutive elk may have a permanent home in the reasonably near future.

Birth of a New Bureau

As a rule, the recommendations of federal study groups and commissions have not, in past years, been accorded the positive action on the part of government that their considered findings might seem to justify. This is for a number of reasons, in part political, and is of little concern here. In any case, the establishment of a Bureau of Outdoor

Recreation in early summer of 1962, pursuant to recommendations of the Outdoor Recreation Resources Review Commission, prompted one prominent Washington conservation figure to remark that "an unusual event has occurred in America: the appearance of an official Federal study recommending a good program which is . . . taken seriously and

put into effect by the Government."

The new bureau, within Secretary Stewart L. Udall's Department of the Interior, is headed by a man highly regarded in the conservation world—Dr. Edward C. Crafts, formerly an assistant chief of Agriculture's Forest Service and a twenty-nine-year career man. The organization has been staffed partly by appointed personnel and partly by transfer of career personnel from other government agencies, this latter process having understandably been cause for some heartburn. Among the bureau's prime purposes: to act as a co-ordinating agency for all government agency activities related to outdoor recreation, and to administer programs of federal assistance to state recreation agencies.

The bureau had barely been clothed with a skeleton staff before bills were introduced into the second session of Congress calling for federal financial assistance to states for outdoor recreation planning, and for a land conservation fund, under which needed federal recreational areas might be acquired for public use as soon as possible.

Both of these bills fell within the purview of the new bureau; both have politically controversial aspects; and neither, in the judgment of this writer, will be acted upon by the 87th Congress. It is reasonably certain, however, that they will again be introduced into the 88th Congress, which convenes in January, 1963, and during the coming year this column will undoubtedly carry additional news concerning their fate.

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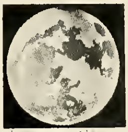

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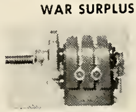

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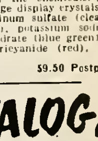

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